AD-A189 003 OPERATION AND MAINTENANCE MANUAL FOR THE NORDA VERTICAL PROFILER(U) NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY NSTL STATION MS B E ECKSTEIN ET AL. JUL 81 1/1

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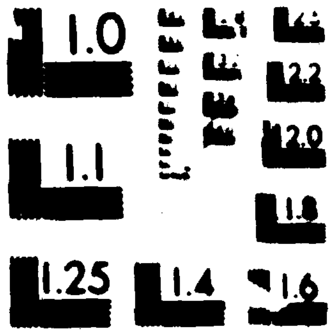
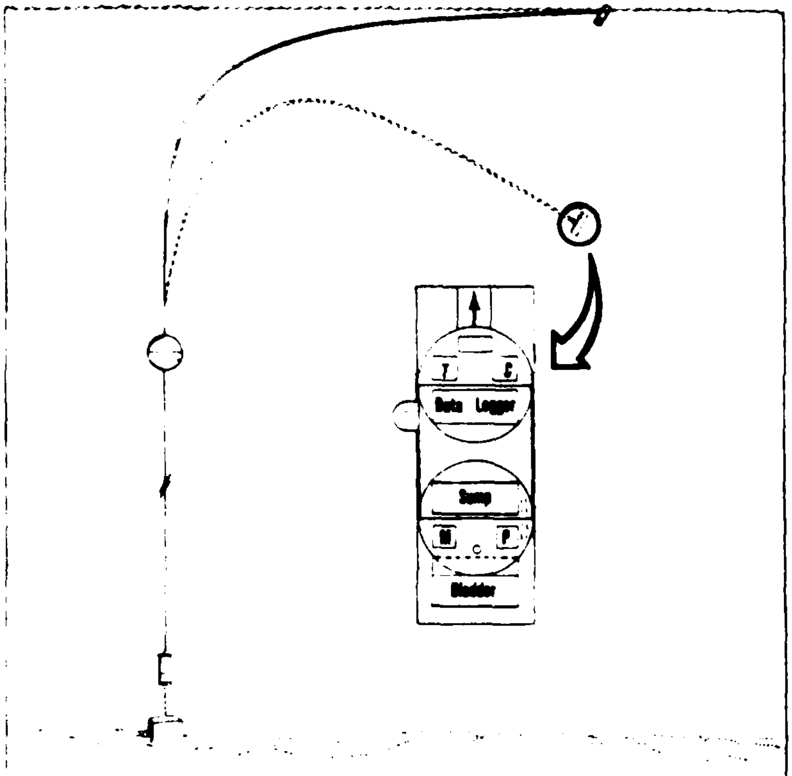


MICROCOPY RESOLUTION TEST CHART

NORDA Technical Note 96

Naval Ocean Research
and Development Activity
NSTL Station, Mississippi 39529

Operation and Maintenance Manual for the NORDA Vertical Profiler



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JULY 1981

EXECUTIVE SUMMARY

The Ocean Programs Office (Code 500) of the Naval Ocean Research and Development Activity (NORDA) provided funds during Fiscal Years 77, 78, and 79 to the Ocean Science and Technology Laboratory (Code 350) for the development of a versatile ocean profiler capable of carrying a variety of sensors. The NORDA Vertical Profiler and associated data readout system resulted from this development effort. The Profiler is capable of making water column measurements from the air/sea interface to a depth of 1000 meters and returning to the surface approximately 20 times before its lithium energy source is expended. Sea tests have been conducted using temperature and depth sensors with the data acquisition subsystem, and a conductivity/temperature/depth sensor capability is also available. The data acquisition subsystem within the Profiler can accept up to 16 analog inputs properly scaled in voltage, and any number of serially supplied 16-bit digited words. Limited amounts of power are available from the Profiler to power add-on sensors. The Profiler is cycle programmable and can be commanded to ascend and descend at regular prescribed intervals. Data rates, sample intervals, and sample durations are also preselectable. One of the most significant and unique features of this profiling device is its ability to make measurements up to and through the air/sea interface.

The Data Readout Subsystem permits retrieval and printout of sensor data collected by the Data Acquisition Subsystem during profiling operations. This subsystem can easily be interfaced to desk top calculators for automatic processing of data or preparation of digital magnetic tape for data entry into a large computer.

This manual describes the functional operation, interconnections, alignment, checkout, and predeployment procedures needed to make use of the NORDA Vertical Profiler. Because the buoyancy subsystem of the Profiler is based on fluid-induced volumetric changes, there are maintenance requirements typical of hydraulic systems. In addition, the self-contained battery subsystems, which supply energy to the various valves, pump, motor, control and sensor electronics, require replacement or recharge on a periodic basis. It has been a primary goal in developing this manual to preserve the detailed information necessary to proper maintenance and operation of the Profiler hardware and not to describe the spectrum of applications to which this device might be put.

This system is available to ocean researchers. Those having an interest in making use of this system should contact the Ocean Programs Office at NORDA.

CONTENTS

ILLUSTRATIONS

1.0 INTRODUCTION

1.1 SYSTEM PURPOSE

The NORDA Vertical Profiler is a variable buoyancy vehicle capable of sampling a water column from the air/sea interface to a maximum depth of 1000 meters on a preprogrammed interval and storing the collected data on an internal cassette tape recorder. An optional configuration that could be developed would be to transmit the recorded data via a satellite to a remote station at each return to the surface. The system concept is shown in Figure 1.1.

1.2 SYSTEM FEATURES

Profiling with a single sensor package can provide definite cost advantages over the use of distributed sensor arrays involving many stations, provided the environment being measured changes slowly compared to the profiling rate. There are a number of advantages inherent in data collection by vertically profiling when using the concept of Figure 1.1.

(1) An ability to profile to the air/sea interface.

(2) An easy method of deployment and recovery.

(3) Reasonably long-term, unattended operation.

(4) Modular arrangement for ease of modification.

(5) Relatively low cost to minimize investment risk if lost.

The profiling system consists of a variable buoyancy vehicle which contains the ballasting and data collection subsystems and the mooring system that holds it in place. The profiler is normally tethered with a buoyant line from a taut-moored, subsurface float, as shown in Figure 1.1, and deployment is by the anchor-last technique. The length and buoyancy of the tether, which connects the profiling vehicle with the subsurface float, can be adjusted to suit the profiling depth range desired. By adding small floats to the tether, the vehicle "hangs" suspended like a small weight on a cork. The addition of an acoustic release mechanism(s) at the dead weight anchor permits easy recovery of the system.

The vehicle itself consists of two spherical compartments arranged vertically in a fiberglass framework, as shown in Figure 1.2. The upper pressure sphere contains the data collection instrumentation and profiling controls, while the lower sphere houses the variable buoyancy system. This buoyancy system works by pumping oil from an internal sump to an external bladder, thereby changing the displacement and buoyancy of the entire vehicle. As the external bladder fills with oil, the vehicle becomes positively buoyant. To cause the vehicle to submerge, an appropriate valve in the buoyancy control system opens, and oil in the external bladder is forced back into the internal sump by the ambient water pressure. Therefore, the pump is used only to force oil into the external bladder when positive buoyancy is required. To submerge the vehicle, then, water pressure does the work, thereby conserving battery power. Even at the air/sea interface, there is enough sea pressure "head" to return the oil to the internal pump. The buoyancy system of the profiler is capable of a ten pound (4.4 kg) buoyancy change of ± 5 pounds (2.2 kg) about neutral buoyancy. About 20 profiles to 1000 meters are possible with the present lithium battery pack, which translates to 40 profiles at 400 meters or 80 profiles at 250 meters.

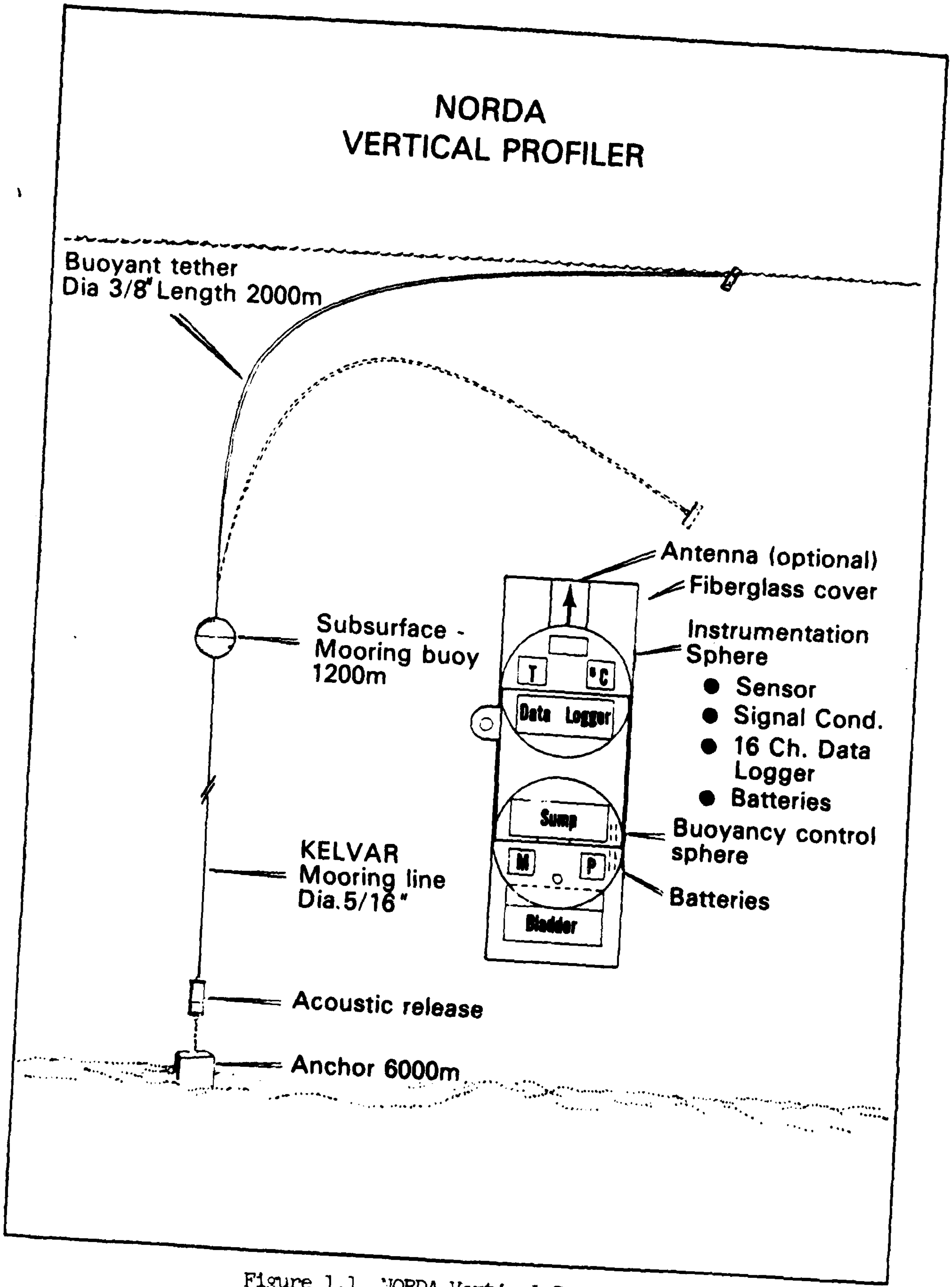


Figure 1.1 NORDA Vertical Profiler

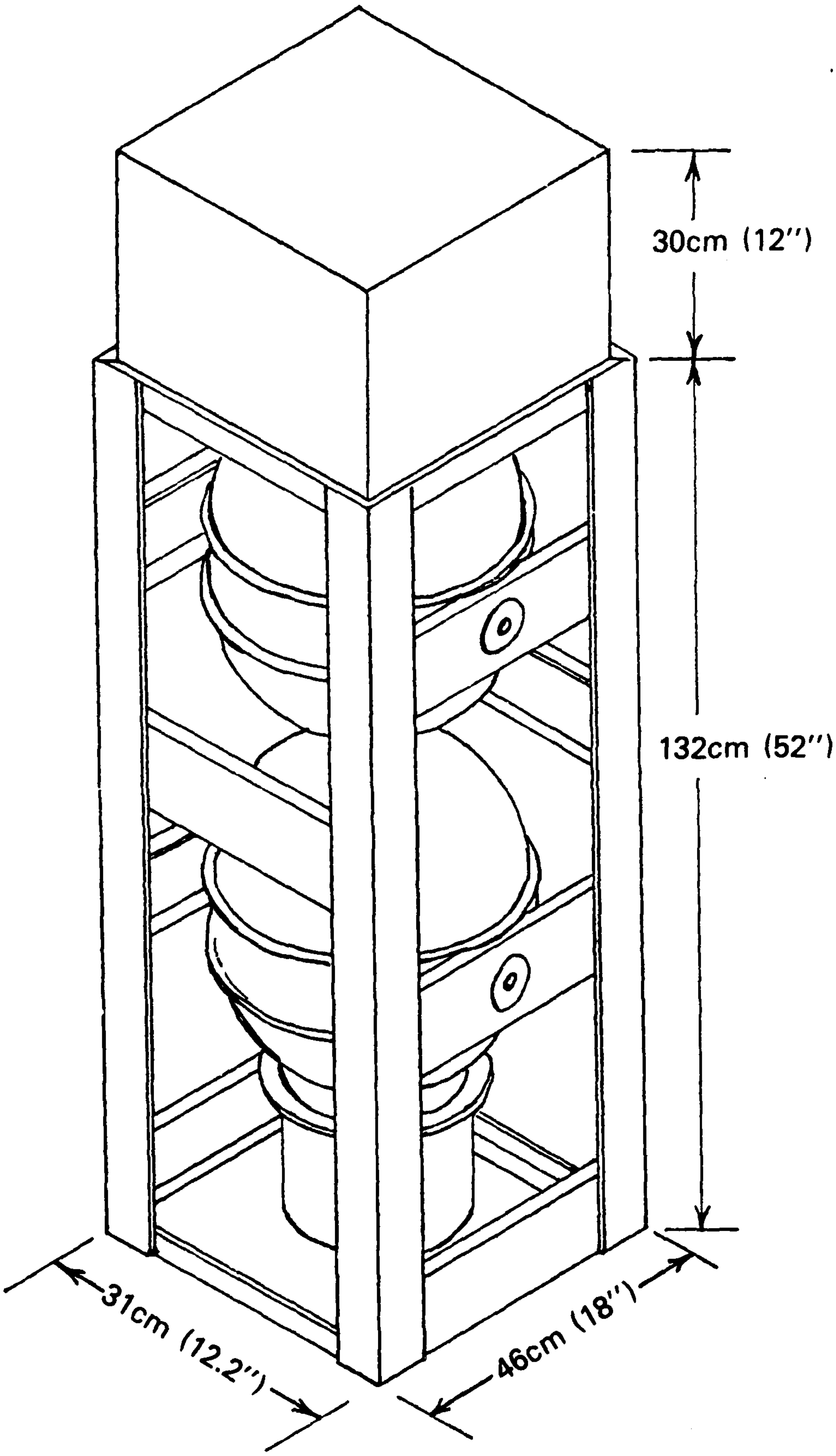


Figure 1.2 Vertical Profiler Mechanical Arrangement

The upper sphere (Figure 1.1) contains a modular data acquisition and control system. The major functions performed by this system are described in section 1.1. The clock portion of the controller provides the time base for data acquisition functions, time tagging of collected data, and initiation of dive and surface commands. The present experimental model has sensors to measure vehicle depth (pressure) and heading (magnetic), and water column temperature. Other sensors to measure vehicle depth (pressure) and heading can be added or substituted rather easily, since the data logger will accept either analog or digital signals, and a number of analog channels are presently unused.

A data playback and printout system was also developed for analysis of the engineering data produced during laboratory and field tests. This system consists of a cassette tape reader, a code converter, and a BCD printer. The code converter acts as the playback controller by initiating tape read commands to the reader and print commands to the printer. Since all of the recorded digital data is not of the same coding format, the code converter also converts all data to a binary coded decimal (BCD) format.

1.3 PERFORMANCE CHARACTERISTICS

In accordance with manufacturers' data and vertical profiler test results, performance data about the system follow:

Physical Size (excluding tether, beacon transmitter, and lights)

Vertical length: 64 inches (162 cm)
Front width: 21 inches (53.3 cm)
Side width: 18 inches (45.72 cm)
Weight: 335 lb (151.95 kg)

Diving Characteristics

Maximum depth: 3280 ft (1000 meters)*

Descent/Ascent Cycling Options: With the present Lithium battery pack a limited number of descent/ascent cycles are possible; however, by reducing the depth of descent, the user has more profile cycles available per battery pack:

Depth	Minimum Number of D/A Cycles
3280 ft (1000 mtrs)	20
1640 ft (500 mtrs)	40
820 ft (250 mtrs)	80
410 ft (125 mtrs)	160
205 ft (62.5 mtrs)	320

Cycle Durations: A "descent duration" is the time for one descent/ascent cycle. There are seven possible cycle durations": (in hours) 1, 2, 4, 6, 8, 12, and 24

Descent Durations: A "descent duration" is the time the vertical profiler (VP) is left at its desired depth. It starts at the beginning of descent and ends with the beginning of ascent (turning on the buoyancy pump). There are seven possible "descent durations": (in hours) 1/2, 1, 2, 3, 4, 6, 12. A "descent duration" should be programmed to be less than the "cycle duration."

Descent/Ascent Rate: Approximately 1 ft/sec (0.3 m/sec) with a variation of ±6 inches/sec (0.15 m/sec). (Factors affecting D/A rate are currents, mooring stability, tether impedance, and others.)

Overdepth: This is a programmable feature that prevents the VP from sinking deeper than desired (i.e., if the tether should be sheared while in the descent mode). When this feature operates, the VP is automatically returned

*If the CTU-8, conductivity/temperature probe, is attached, maximum depth is 1000 ft (304.8 mtrs).

to the surface before the scheduled "cycle duration" has elapsed and the profiler is prevented from further decents.

Data Acquisition Capabilities

Types of data

(1) HEADING: 0° to 360° measured in 1.4° increments.

(2) PRESSURE (DEPTH): 0 to 2222 ft (0 to 677.26 m) measured in 1.1011 ft (33.56 cm) increments.

(3) TEMPERATURE: 0° to 41.67° (C) (32° to 107° (F)) measured in 0.0197 (C) (0.0354° (F)) increments.

(4) HYDRAULIC PUMP MOTOR: Sensed Voltage = 0 to 25V measured in 0.0244V increments; Current=0 to 9a in 22 ma increments.

(5) TIME in days, minutes, and seconds.

Storage medium: Magnetic tape; LPS-16A, Datel Systems, Inc.; using Phillips type cassette with 2 tracks.

Data channels: 16 analog-to-digital; random access; accepts +5Volt analog input; 11 channels are presently unused and available for user's needs.

Data Rate: 5 (16 bit) words/second

Word Format: 16 bits; 4 address bits and 12 data bits in binary code format.

Tape storage capacity: 120,000 (16 bit) words, including gaps and load forward.

Data Recording Time Intervals: 10 sec, 30 sec, 1 min, and 2 min. Note: One complete scan of all data parameters is performed each interval.

Auxiliary Serial Data Input: Permits cassette recording of external digital data, such as time and heading.

Power Source

Upper sphere (Data Acquisition & Control): Rechargeable Gel-Cell battery packs, three separate units at 12VDC each arranged to give +12VDC, -12VDC, and +24VDC.

Lower sphere (Buoyancy Control System): Lithium batteries (20); 20 amp-hours @ 5 amp drain. Batteries arranged in four packs of five cells each at nominal voltages of +12VDC and +24VDC

2.0 SYSTEM CONFIGURATION

2.1 GENERAL

The Profiler consists of a structural framework supporting two pressure-proof housings and flotation material for establishing neutral buoyancy of the assembly (see Fig. 2.1). One pressure-proof housing (lower sphere) is the buoyancy control housing that contains the hydraulic system for adjusting the Profiler's net weight in seawater, while the other, main control housing (upper sphere), contains the timing and sensing electronics together with the data recording system. In the following paragraphs each of the major subsystems will be discussed individually.

2.2 BUOYANCY CONTROL SYSTEM

The basic elements of the buoyancy control system are the high pressure pump, oil, sump, valves, and the external bladder. Incidental elements include oil filters, check valve, pump drive switching electronics and the energy source. (see Fig. 2.2).

2.2.1 Hydraulic System

The various components will be discussed in subsequent paragraphs; but in general the hydraulic system functions in the following manner:

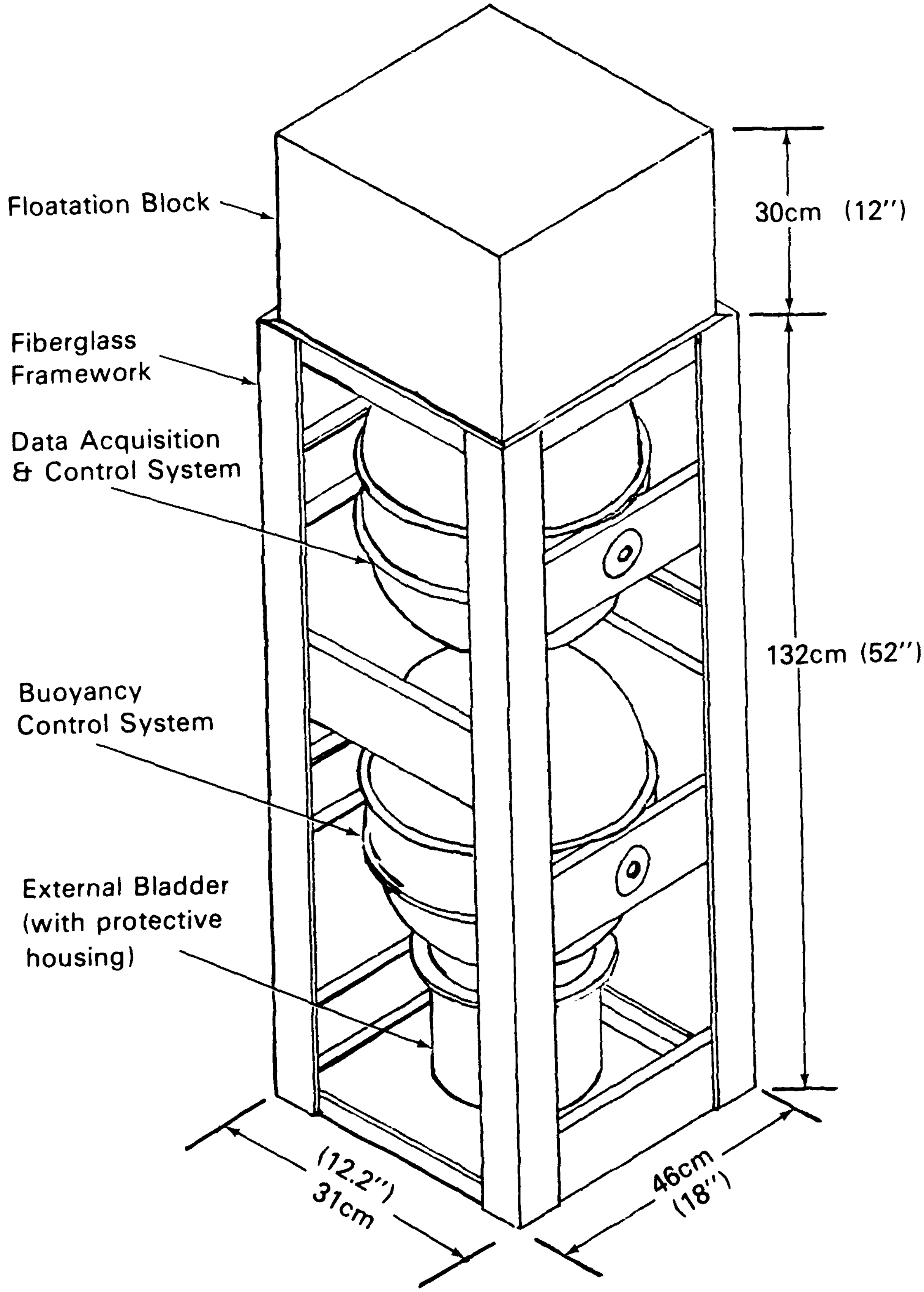


Figure 2.1 Vertical Profiler Assembly

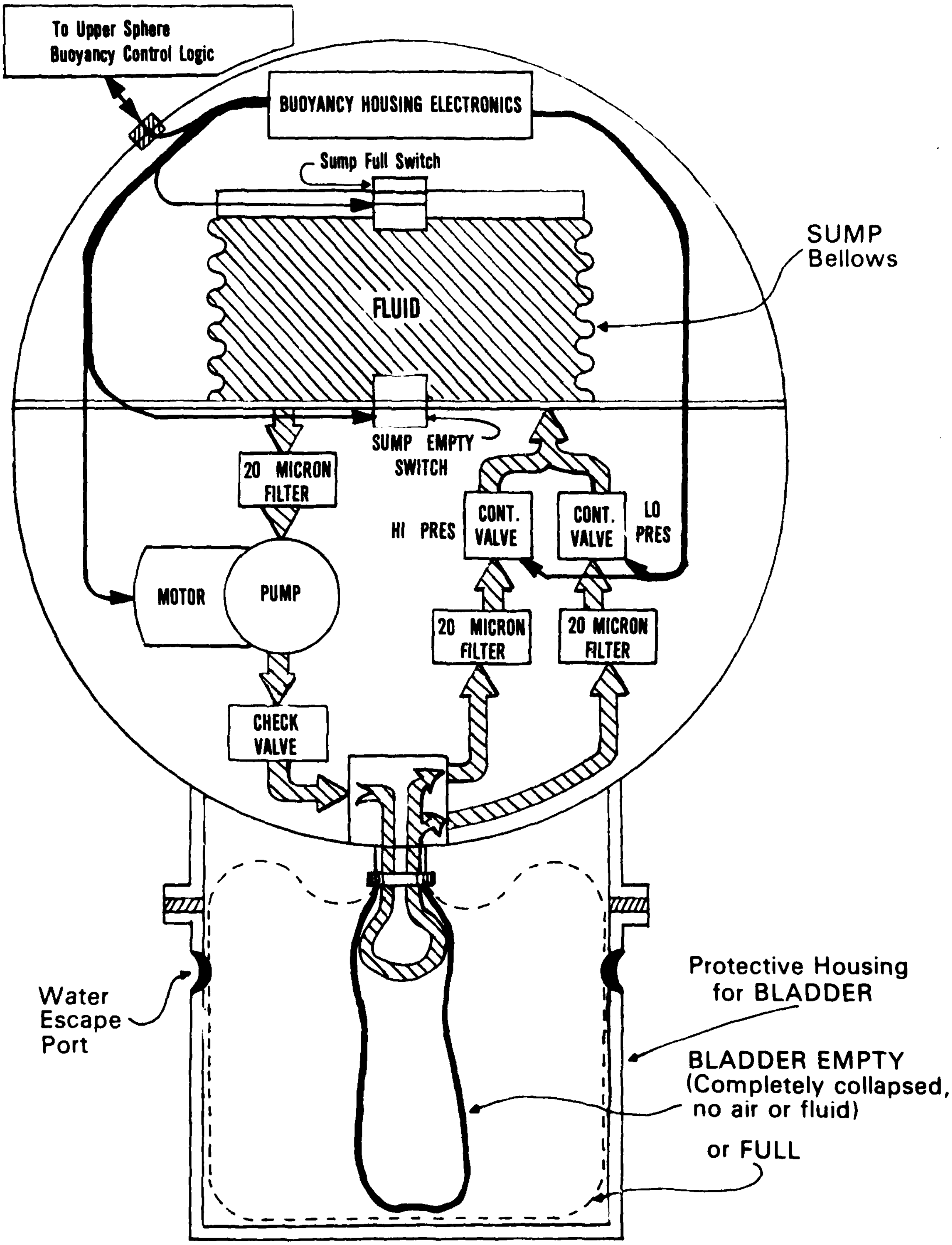


Figure 2.2 Buoyancy Control System (lower sphere)

When the external bladder is full, the net system buoyancy is 2.2 kg (5 lb), and the Profiler will be on the surface. The physical position of the bladder in the Profiler puts it approximately 1.5 m (5 ft) below the surface. The internal pressure of the buoyancy control housing is one atmosphere. When the valves are opened, sea pressure causes the bladder to collapse, forcing the fluid into the sump, which expands linearly until a limit switch closes the valves. With the bladder thus collapsed, the system is 2.2 kg (5 lbs.) negative and submerging.

When the pump is started, on command of the control system, it extracts oil from the sump and delivers it to re-expand the bladder at depths to 1,000 meters. When the sump is emptied of 4.4 liters, as indicated by a lower limit switch, the pump is stopped. The bladder again provides the system with a net buoyancy of [illegible], causing ascent.

. . . Pump Motor

The pump is a [illegible] PM-[illegible] axial piston pump with a wrench adjustable variable displacement, at constant rpm. It is driven by a 1/4 hp, 24 volt, permanent magnet [illegible] coupled to the pump. The capacity was adjusted to be 0.38 liters/min [illegible] at [illegible] rpm, which is within the motor's output capacity when pumping [illegible] of [illegible] m ([illegible],500 psi).

The pump has close running tolerances, and the manufacturer recommends that the oil be cleaned to 20 microns. Therefore, three 20-micron filters have been installed in the hydraulic system: two prior to the Skinner control valves, and one prior to the hydraulic pump. NOTE: Filter cleanliness is very important to proper pump operation. Once they are removed, they can be cleaned by reverse flushing or [illegible] cleaning in a solvent such as mineral spirits.

. . . Internal Sump

A bellows was selected for the fluid sump due to the need for linear expansion and contraction of the sump with volume changes to accommodate limit switches at the ends of the pumping and refilling sequences. Bellows also offer minimum resistance for expansion and contraction cycles.

The bellows is fabricated from type 347 stainless steel. It is mounted in the hydraulic system with high and low limit switches that are set to provide the correct exchange of fluid for buoyancy control and to keep the bellows within its specified travel limits.

The minimum level switch is internal and should never need adjustment, nor can it be adjusted without breaching the hydraulic system by removal of the upper bellows cap. The maximum level limit switch is adjustable by changing the position of the switch portion of the two-part magnetic proximity switch on the terminal board TB 201.

The lower level, where the magnetic switch turns the pump off, is set 178 mm below the top of the bellows guide. The upper level, where the magnetic switch closes the valves, is set at 32 mm. The total fluid exchanged in this 146 mm expansion is 4500 ml, which will result in a net change in buoyancy of the system in sea water of 4.62 kg. This exchange volume will remain constant for all cycles unless the switch settings are changed.

2.2.4 Valves

The valves are Skinner solenoid valves designed to seal against 210 kg/cm^2 (3000 psi). There are two valves in the system, one of which has a 0.8 mm diameter orifice and opens against a pressure differential up to 175 kg/cm^2, and the other has a 2.0 mm diameter orifice which opens only at pressures less than 14 kg/cm^2. The valves are connected in parallel and operate simultaneously to allow the return of oil to the sump. The two sizes assure that the system will continue to cycle if, for some reason, the Profiler failed to return fully to the surface during an ascent phase but remained more than 150 m below the surface. For example, let us assume the situation shown in Figure 2.3.

Figure 2.3 shows the Vertical Profiler (VP) being used to examine a column of water existing from the surface to a maximum depth of 600 m. Ideally, the VP would be moored by buoy A' and would cycle between B' and C'. Ideally, that is, if we assume the ocean current to be negligible. If, however, we assume a strong ocean current, the profiling situation changes. The effects of drag caused by the strong current have been greatly exaggerated in Figure 2.3. Here is an explanation of the Vertical Profiler operation summarized by the problem described in Figure 2.3:

(1) Let us start by assuming a no-current cycling condition as shown by A', B', and C' as shown in Figure 2.3.
(2) When the profiler is on the surface (B'), the
  (a) external bladder filled with fluid; (the upper bellows sump is empty;)
  (b) VP is buoyant;
  (c) pump is not running;
  (d) and the Skinner control valves are closed.
(3) To submerge the VP (to C'), the
  (a) valves are activated to the open position, and fluid starts flowing from the external bladder through the valves to the upper bellows;
  (b) pump is off and the checkvalve (see Fig. 2.2) prevents fluid flowing back through the pump;
  (c) bellows sump fills until the "SUMP FULL" switch causes the valves to close;
  (d) and the VP submerges until the length of tether and mooring buoy restricts further descent (600 m in this case.)
(4) To cause the VP to surface (back to B'), the
  (a) valves remain closed;
  (b) pump is turned on;
  (c) and fluid flows from upper bellows sump to external bladder.
(5) When roughly half the fluid from the sump flows into the bladder, the VP becomes buoyant and starts to surface.
(6) When the upper bellows sump is empty, the "SUMP EMPTY" switch activates the buoyancy control logic to turn off the pump.
(7) With valves still closed, pump off, and external bladder full, the VP returns to the surface (B').

Let us now assume that a strong current is flowing after the VP has been submerged to 600 m, as shown in Figure 2.3. We will consider the moored buoy to be at A instead of A' and the new profiling cycle to exist from 300 to 600 m (B to C).
(1) The VP is submerged at 600 m (C), and the
  (a) bladder is empty;
  (b) pump is not running;
  (c) valves are closed;
  (d) and the upper bellows sump is full.

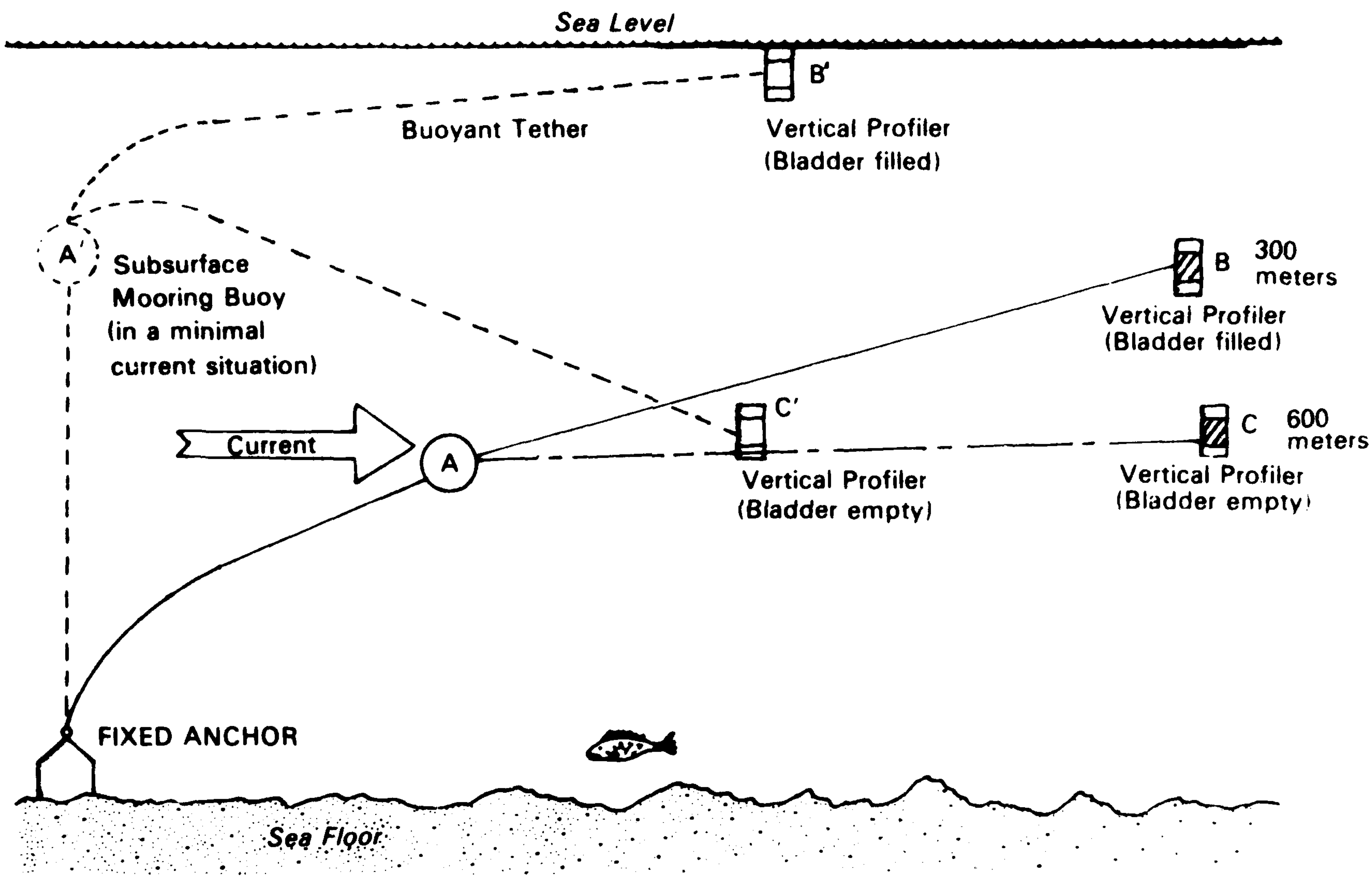


Figure 2.3 Dual Control Valve Operation

(2) The VP starts an ascent cycle, so the
  (a) valves remain closed;
  (b) pump turns on;
  (c) and the upper bellows sump starts to empty into the lower external bladder.
(3) The VP ascends (toward B), and the
  (a) bellows sump is empty;
  (b) and the pump turns off.

Now as shown in Figure 2.3, the VP rises only to 300 m because of the strong current limiting the tether movement. Assuming normal operating procedures, the VP would have been programmed to do more than one ascent/descent cycle, so another descent cycle would begin after some time. When starting a descent cycle, the control valves are activated to the open position to let fluid flow from external bladder to upper sump. However, only the small orifice valve (0.8 mm) will respond because of its high pressure capability-175 kg/cm^2. The Lo-Pressure valve, with the 2.0 mm orifice, will not open at the present depth of 300 m because of the 30 kg/cm^2 head. This means the fluid will drain from the external bladder to the bellows sump, but more slowly than normal. Thus, the reason for the two valves (in parallel) is this: if only one valve were used (preferably the large orifice type because of its higher flow rate) and the VP were caught in a strong current condition, the VP would not be able to cycle more than once while in this situation. The inability to completely come to surface should not inhibit the VP from profiling the remainder of the desired water column. Since the low-pressure valve becomes inoperative at depths greater than roughly 150 m, the high-pressure valve still allows for cycling from 150 to 1000 m, which constitutes 85% of the possible 1000 m column.

The 0.8 mm diameter orifice is a potential problem if there are any loose particles in the oil that could block the orifice and prevent valve closure. The 20 micron filter prior to the valve will prevent blockage if it is properly maintained.

The valves have Magnelatch (r) operators requiring only a pulse of DC current in one direction to open the valve and to leave it open, and a current pulse in the opposite direction to close the valve. Their operation is discussed further under the electrical section.

2.2.5 Bladder

The bladder is the only part of the hydraulic system that is external to the buoyancy control housing. It is a 9.5 liter, Buna N, hydraulic accumulator bladder. There is a fiberglass cylindrical housing surrounding the bladder to prevent damage to the bladder.

2.2.6 Energy Source

The space available in the buoyancy housing provides for the inclusion of 20 lithium cells (Power Conversions, Inc., Model No. 660-5A), which have a capacity of over 20 amp hours at a 5 amp drain. They are arranged in two parallel packs of 10 cells having a voltage in excess of 28 VDC.

Life tests were run on one set of batteries under actual loading conditions, and it was determined that 20 pumping cycles could be achieved from a fresh battery at depths of 1,000 m. It was also determined that new cells or cells that have been in long-term storage require a burn-in period of heavy current drain for a few minutes to remove internal oxides that cause high internal resistance and prevent the cells from operating at their rated output voltage.

Indications are that depths shallower than 1000 m are likely for most Profiler operations. Under conditions where the maximum depth of each cycle is 300 m, the reduced current required for the pump motor is less demanding on the battery and its capacity is increased. This, coupled with the lower drain rate, results in predictions of 75 or more cycles to 300 m with this 20-cell battery.

2.2.7 Hydraulic Fluid

Exxon's "Univis J-13" (formerly J-43) is presently used in the system. It is a light weight oil which has a uniform viscosity over a wide temperature range---an ideal characteristic for the Profiler's operation.

2.2.8 Electronics

The electronics in the buoyancy control housing consist of only those components necessary to operate the pump motor and the valves on commands from the main control housing. Most of these electronics are mounted on a single circuit board, together with an on-off switch and circuit fuses. This circular circuit board is mounted on top of and is concentric with the sump enclosure. Other elements of the system, such as the motor relay, sump limit switches, motor current sensing resistors, and main battery fuses and diodes, are mounted elsewhere in the system. Figure 2-4 is the schematic diagram of the electrical circuit in the buoyancy housing.

The following is a brief description of the components and circuit functions.

The Magnelatch valves are polarized latching valves with colored leads to identify the polarity. These valves normally operate with a 12 volt level. The red leads of the valves are connected to the +12 volt center tap of the +24 volt battery and, if the black lead is switched to common, the valves will be pulsed open; if the black lead is switched to +24 volts the valves will be pulsed closed. Transistors Q1, Q3, and Q5 make up the open valve drive circuit and Q2, Q4, and Q6 make up the close valve drive circuit. The latching voltage is applied to these circuits for less than one second each time the valves are ordered to open or close.

The pump motor draws heavy continuous current when running, thus requiring a power relay. When the pump is ordered on, transistors Q7 and Q8 are used to energize power relay K201. The pump motor has thermal overload contacts that open if the motor overheats.

If these contacts open, the input to NOR GATE 0101-12 goes LOW and the flip-flop circuit output pin 0102-3 goes high, preventing the pump-on signal from starting the pump motor until the circuit has been reset (see control housing.)

The internal oil sump has two magnetically operated limit switches which are used to signal the electronics in the control housing when the sump becomes full or empty. The flip-flop 2701, the binary counter 2401, and the three, two-input NOR GATES on 0101 all combine to pulse the sump switches about once a second either when the pump is running or when the valves are latched open. This switch sampling circuit is helpful to reduce battery drain when the system is at rest between cyc

The main battery contains 20 lithium cells which are grouped together in five-cell packs. The five cells in each pack are connected in series, and then two packs are placed in parallel to provide the upper half of the 24 volt supply. Diodes are placed in the output of each five-cell pack to prevent reverse current in the cells if one pack has a greater potential than the other.

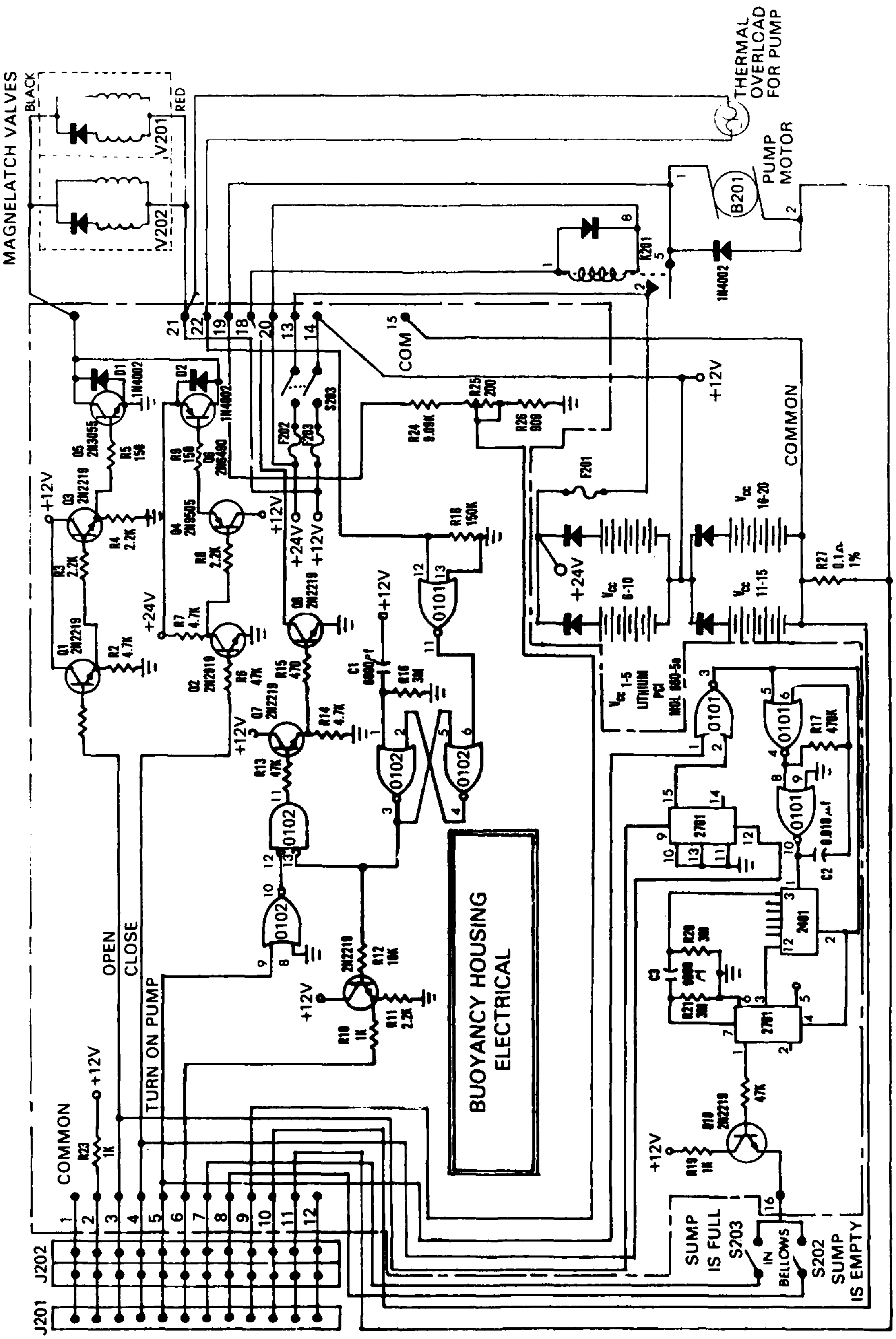


Figure 2.4 Buoyancy Housing Electrical Schematic

2.3 MAIN CONTROL/RECORDER HOUSING

The control housing contains all the timing circuitry for programming and controlling data-recording sequences (refer to Figure 2.5 for block diagram). The housing contains its own rechargeable battery packs, making it independent of the high-capacity battery in the pump housing. These components and circuitry, together with a Datel Incremental Recorder and a Digicourse Magnetic Heading sensor, are mounted on a single, flat-plate chassis which is bolted in the center ring of the housing.

The center ring has two 12-pin electrical penetrations. One penetration interconnects the main housing, via optical isolation circuits, with the buoyancy housing for transmitting control signals and receiving performance status. The other penetration has a mating connector with cable terminating in 12 single-pin, pressure-proof connectors. Two of these are used for the external temperature sensor, and the remainder are capped and available for any other external sensors that may be installed.

The electronics circuitry is shown on C & M System's schematic diagrams, drawing Nos. D-BD-1223, D-BC-1224, C-BC-1225, C-BC-1226 and D-1850-1. The major features of these systems are discussed in the following paragraphs. See Figures 2.6 and 2.7 for a physical layout of the electronics in the upper sphere.

2.3.1 System Timing

All timing functions required for the Profiler are derived from the basic timing portion of C & M Systems Time Code Generator (TCG), which references a stable 2 MHz clock oscillator. The timing portion of the TCG is contained on a single printed circuit board. The circuit is shown on C & M Dwg. No. D-1850-1. Portions of this drawing which are not applicable to the Profiler system are also noted.

The timing data output of this timing board is in a binary coded decimal format, which is decoded to decimal information in the 4028AE BCD to DECIMAL decoders located in the buoyancy control logic board (Wire wrap bd. TB 102). This decimal equivalent of time is compared with the settings of two DIP switches on the same board for intitiation of operating cycles. The operator sets the DIP switch to the time of day (on the hour) when he wishes the initial descent to start. He then synchronizes the timing circuit to agree with local or reference time and starts it counting. When the timing circuit output matches the DIP switch settings the first cycle will be initiated (see Fig. 2.8).

Cycles of descent and ascent will continue at programmed intervals as selected by setting of two seven-position DIP switches also located on TB 102.

One DIP switch is used to select full "cycle duration." That is the time from when the valves are first opened, causing descent, until they are to be opened again. The seven possible "cycle durations" switch settings are 1, 2, 4, 6, 8, 12, and 24 hours. The other DIP switch is used to select "descent duration." That is time from when the valves are first opened (as with "cycle duration") until the pump is to be started for ascent. The seven possible "descent duration" switch settings are 1/2, 1, 2, 3, 4, 6, and 12 hours. It should be obvious to the operator that the setting for "cycle duration" must be greater than the setting for "descent duration" for logical performance.

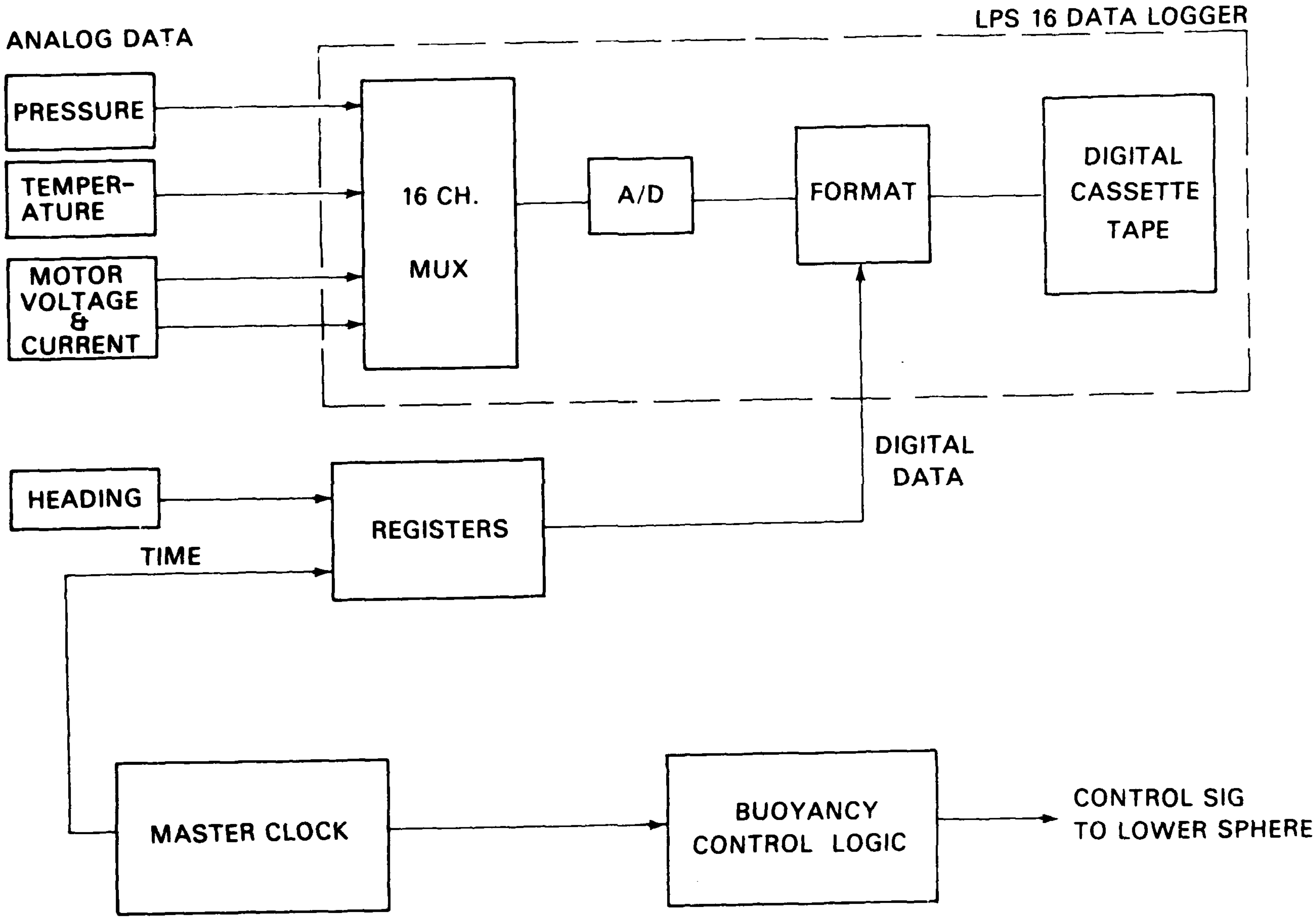
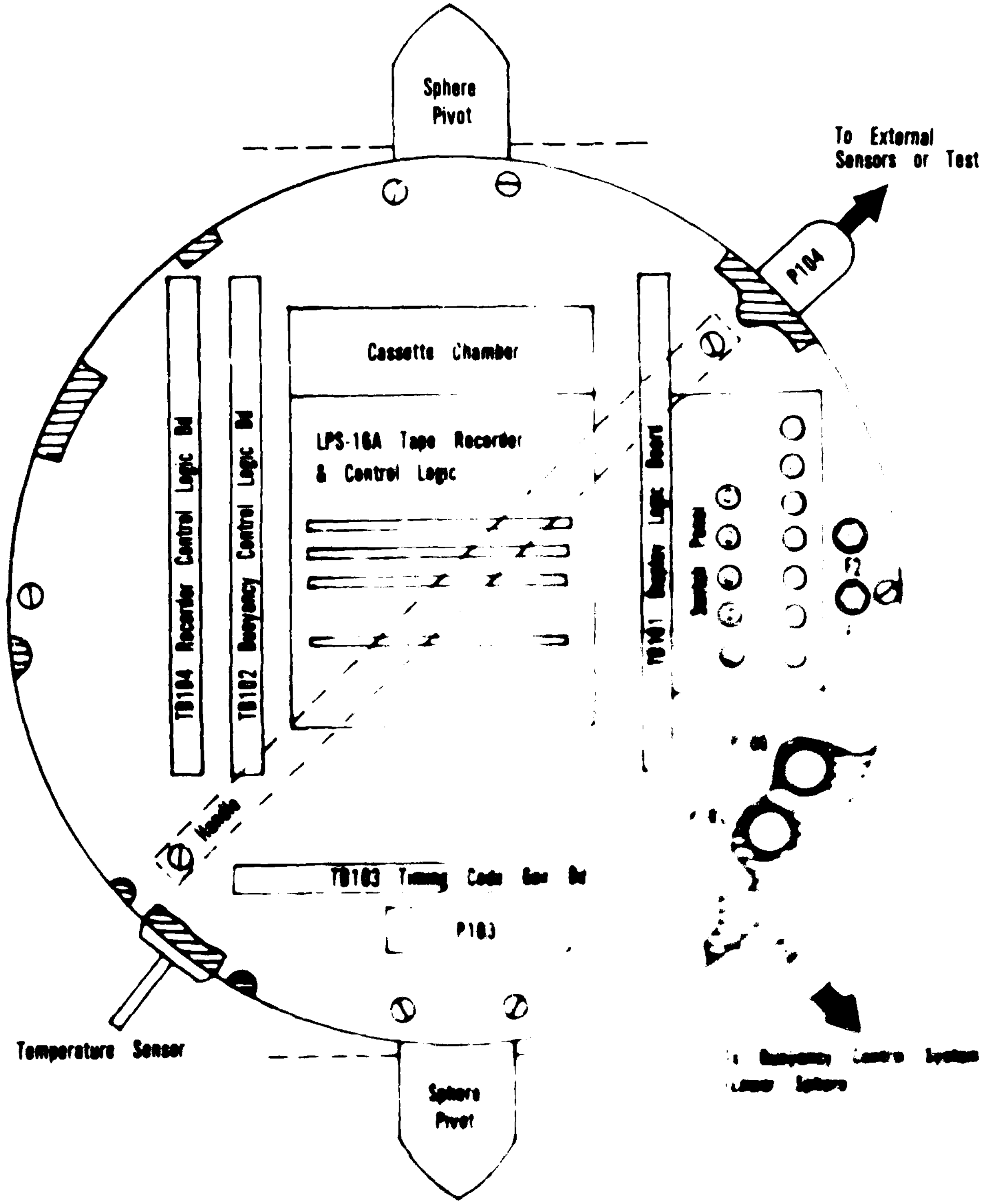


Figure 2.5 Data Acquisiton and Control System (upper sphere)



Sphere Pivot
To External Sensors or Test
P104
Cassette Chamber
LPS-16A Tape Recorder
& Control Logic
TB104 Recorder Control Logic Bd
TB102 Buoyancy Control Logic Bd
F2
Handle
TB103 Timing Code Gen Bd
P103
Temperature Sensor
Sphere Pivot

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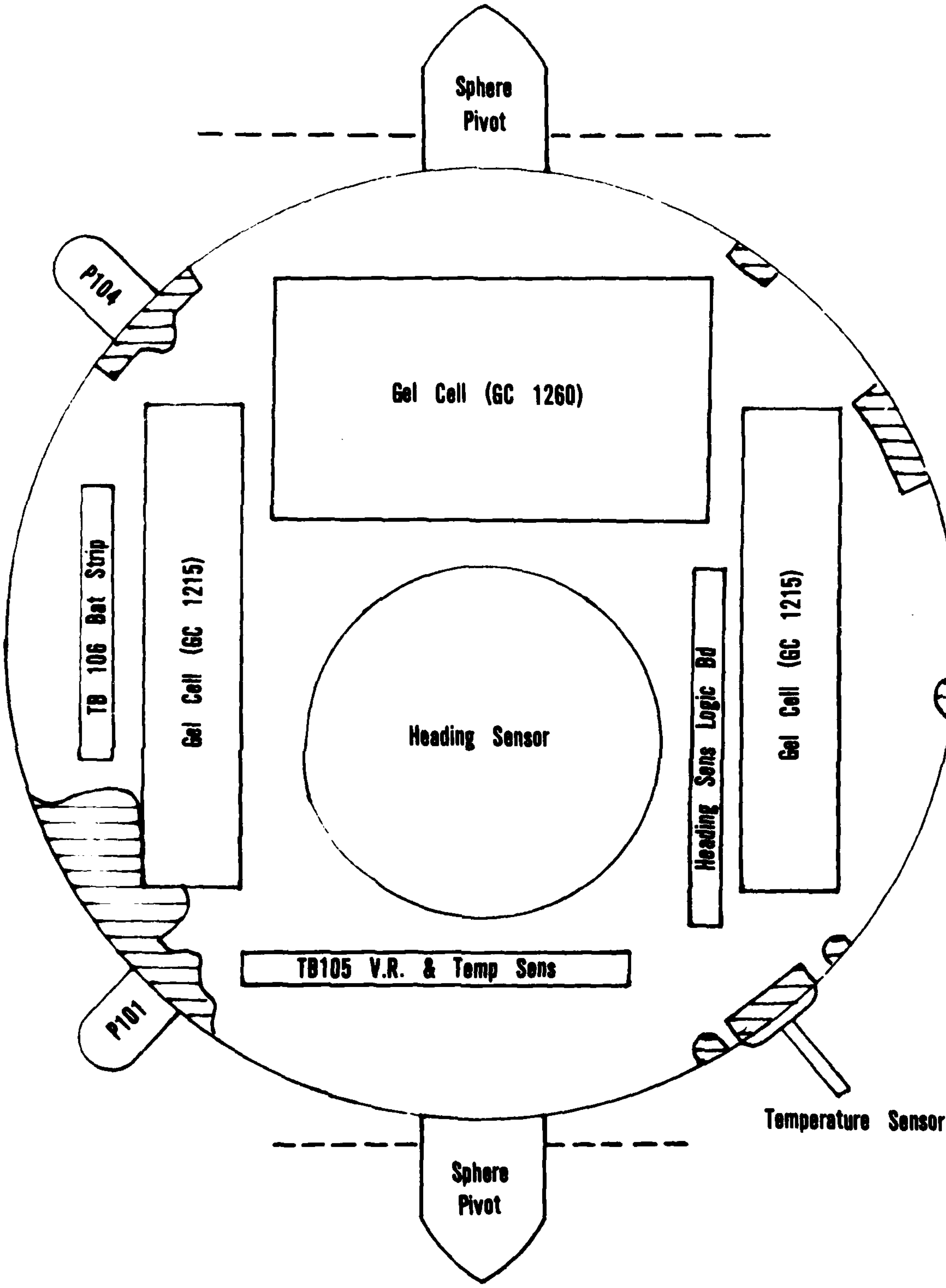


Figure 2.7 Bottom View of Chassis within Main Control Housing (upper sphere)

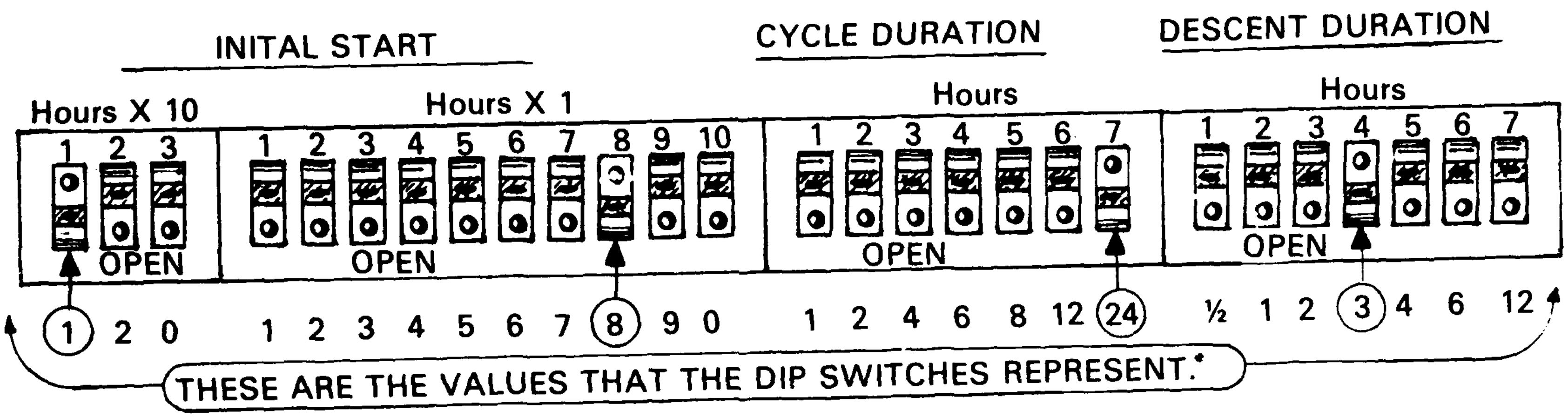


Figure 2.8 TB102 DIP Switch Settings

2.3.2 Switch Panel

There is a switch panel on the chassis which permits the operator to set up Profiler timing (see Fig. 2.9). With it he can control the pump and valves to check out the buoyancy control functions independent of timing circuits and to control the operation of the recorder. The functions of the various switches are described in the following paragraphs.

Power on switch connects the +24 and +12 internal batteries to distribution terminal board TB103 and connects the -12 internal battery to the negative 5 volt regulator on TB105.

Display power switch in the ON position applies power to the L.E.D. display, which allows the operator to read the time stored in the time code generator and to observe the clocking second-by-second (see 2.3.3). The display permits readout of days-hours-minutes-and-seconds and is essential for following the cycling and the timed events during program checkout. Power for the display is supplied by the +12 volt battery and should be left in the OFF position at all times when not in use.

Reset switch is a momentary contact type which, when placed in RESET, causes all the registers in the time storing circuits to reset to a zero time reference and resets all the circuits in the control housing to the standby condition. When the reset switch is closed, the pump is ordered on and will transfer the oil from the internal pump to the external bladder in preparation for the launch. Each time control housing power is interrupted, it is necessary to reset the system to eliminate the possibility of a random condition being stored.

Start switch is a momentary type which, when placed in the START position, sets a flip-flop allowing the timing circuit to accurately add time to the registers.

Fast Time switch is used during testing or maintenance to accelerate time by a factor of 100, i.e., one hour of real time can be simulated in 36 seconds. The fasttime switch should be used only to compress the time between timed events and should be returned to the normal position when these events are to take place to allow adequate time for timing circuits to perform.

Stop time switch is used during testing or maintenance to inhibit the advance of time if the operator wishes to examine any position of the program in detail.

Pump on and Pump off allow manual operation of the pump motor during installation and checkout procedures.

Valve open and Valve closed allow manual operation of the valve positions during installation and checkout procedures. A lighted L.E.D. between these two switches indicates that the valve has been pulsed to open.

Load forward will energize the recorder drive motor and is normally used to drive the recorder when a new tape is inserted in the machine. A new tape has a clear leader, and it requires one or two minutes to transfer this clear leader to the take-up reel.

Recorder inhibit. This switch interrupts the timing input that originates a recording cycle. It prevents the recorder from operating and the pressure transducer, heading sensor, and temperature circuit remain in the OFF condition.

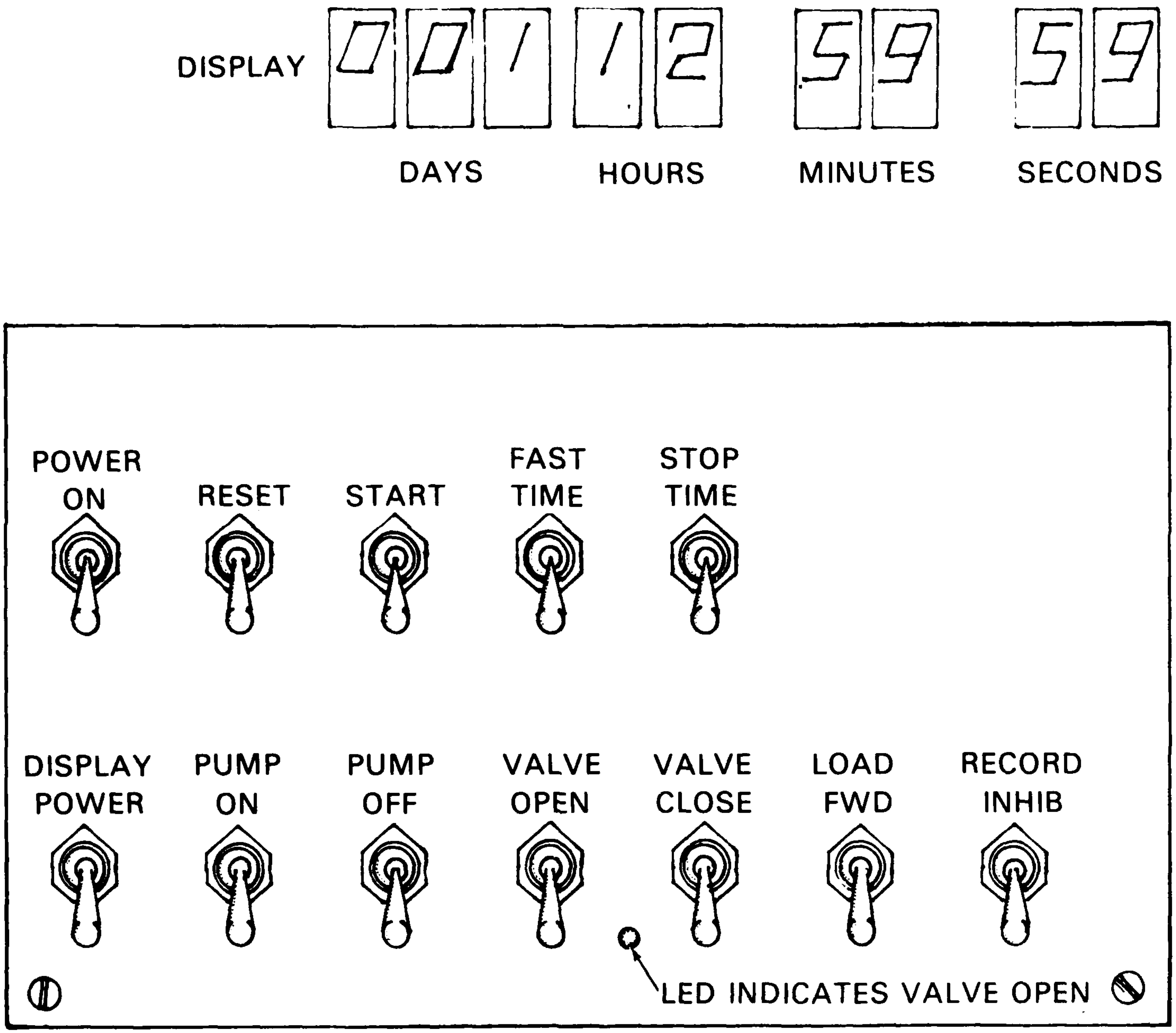


Figure 2.9 Display and Switch Panel

2.3.3 Timer Display

The printed circuit timer display board is mounted vertically on the chassis and is hardwired in place. It contains nine 7-segment L.E.D., numerical, plug-in display lamps. The decoder driver for each readout is included in the lamp package. These readout assemblies require a 5 volt supply for display power and a BCD input signal. The BCD signals which are supplied by the time code generator for days, hours, minutes and seconds are delivered to the display board at the 12 volt level. Five 4010 AE buffer amplifier level converters, 1001 to 1005, change the 12 volt BCD signals to the required 5 volt level for the L.E.D. display decoder drivers. There are two 5-volt regulators, VR1 and VR2, on the board that are supplied with the +12 volts when the display power switch is on; they convert this +12 volt level to the required 5 volts for the display readouts and the +5 volt converter level in the buffer amplifiers.

2.3.4 Optical Isolation Circuits

There are six optical isolation circuits in the control housing that effectively isolate any power surges or noise spikes that may be generated in the pump housing or present in the lithium battery power supply. Each optical isolation circuit combines, in proximity, an infrared emitting diode and silicon photo transistor. Optical intercoupling provides a high degree of AC and DC isolation. Signals through the isolation circuits from the control housing include orders to open and close valves and start the pump and signals to the control housing indicating the sump is empty or full.

Presently there are signals that pass from the buoyancy housing to the control housing which do not go through optical isolators. These are engineering data for recording during operational testing, namely, main battery voltage under load and motor current. These lines may be removed at any time without affecting the operation of the system.

2.3.5 Data Storage

The data gathering portion of the Profiler consists of the incremental tape recorder and any sensors or transducers that the user may require. The data gathering portion utilizes outputs of the timing board and shares the battery supply, but is otherwise separated from the buoyancy control system. A four-position DIP switch is used to select the time between each recording period (found on TB104). The available selections are 10 secs, 30 secs, 1 min, and 2 mins. When a recording cycle starts, the power is switched on for the pressure transducer, the heading sensor, and the temperature circuits. After the power is switched on for the sensors, a three-second settling period follows before the recorder is allowed to run. There are two methods of putting data into the Datel incremental recorder. If the data are available as an analog voltage between +5 and -5 volts it can be applied to one of the sixteen analog-to-digital converter inputs and will be stored on tape as a twelve bit binary number. If the data are in digital form, it can be stored in a register and shifted into the auxiliary data input line.

Reference should be made to the LPS-16A Datel Recorder Instruction Manual for a complete functional description of the unit.

The present inputs to the recorder are time, magnetic heading, depth, temperature, battery voltage, and motor current. Data conversion procedures are included in a following section.

2.3.6 Sensors

The sensors are the sources of data and consist of the following type:

(1) HEADING: Obtains heading information in the form of a digital output relative to magnetic north. Transmits heading information in 1.4° increments.
(2) PRESSURE: Obtains pressure (depth) information in the form of an output voltage that varies from +0.065 V to +5.0 V, which represents depths of Ø ft and 2222 ft, respectively.
(3) TEMPERATURE: Obtains temperature information in the form of an output voltage that varies from Ø V to 2.25 V, which represents temperature (C$^\circ$) of 0° and 41.67°, respectively.
(4) OPTIONAL TEMPERATURE/CONDUCTIVITY (Salinity): Obtains both temperature and conductivity as two separate outputs, but from one sensor unit. The outputs are voltages and represent the following information:
    Conductivity Output varies from Ø V to 3.Ø V, representing Ø millimhos to 125 millimhos.
    Temperature Output varies from Ø V to Ø.5 V, representing Ø (C) to 46.1 (C).
(5) MOTOR VOLTAGE (Internally Sensed): Obtains hydraulic pump motor voltage as a binary output that represents a motor voltage from Ø V to 25 V. These data can be stored on tape and used for later analysis.
(6) MOTOR CURRENT (Internally Sensed): Obtains hydraulic pump motor current as a binary output that represents a motor current from Ø amps to 9.5 amps. This data can also be stored on tape and used for later analysis.

2.3.7 Data Conversions

All data are recorded on the Datel incremental recorder in binary code. These data may be translated in a number of ways during playback for analysis. The simplest way is direct printing of binary code, reading it as a decimal equivalent and making an arithmetic conversion to the necessary engineering units. An extension of this procedure would include playback electronics (see section 4.0), to convert the binary number to, and print out of, the decimal equivalent followed by manual arithmetic conversion to engineering units.

The following information presents the conversion constants necessary to convert the decimal equivalents of the binary words on tape to engineering units for manual data interpretation or as input constants for a calculator/computer. Included with the conversion constants are tables and graphs, where appropriate, for the various data channels.

The first and second words recorded on tape are binary coded decimals of time in minutes & seconds and days & hours and no further conversions are necessary.

The third word is a 16-bit word, eight bits of which represent magnetic heading, and the remaining eight bits are wired low. The decimal equivalent of these eight binary bits --- times 1.406 --- equals the magnetic heading in degrees. The following table summarizes the decimal readout in ten-digit increments to the corresponding heading (see Fig. 2.10, also).

MAGNETIC HEADING

Readout		degrees Mag
0000		000°
0010		014
0020		028
0030		042
0032	NE	045
0040		056
0050		070
0060		084
0064	E	090

Readout		Heading
0070		098
0080		112
0090		127
0096	SE	135
0100		141
0110		155
0120		169
0128	S	180

Readout		Heading
0130		183
0140		197
0150		211
0160	SW	225°
0170		239
0180		253
0190		267
0192	W	270

Readout		Heading
0200		281
0210		295
0220		309
0224	NW	315
0230		323
0240		337
0250		352
0255	N	358.6

The remaining data channels are analog inputs and the A-D conversions are performed by the recorder. The first of these channels records submergence pressure and is identified as channel zero (Ø). Subsequent channels are identified as one (1), two (2), three (3), etc. In the following sections the decimal count equivalent of the recorded data is designated as the letter "R".

Channel Ø Pressure (depth)

R of 4096 = +5 volt input ≈ 2222 ft submergence
R of 2078 = +.065 volt " ≈ 0 ft "
Δ R of 2018 ≈ 2222 ft change

$\therefore \frac{2222}{2018} = 1.1011$ ft/unit change in R

$\therefore (R-2078)1.1011$ = Total depth in ft
or $1.1011(r)-2288$ = Total depth in ft
See Figure 2.11 for details

---

likewise $0.335(R)-697.6$ = Total depth in meters

Channel #1 Temperature

R of 1577 = 0°C.
R of 3277 = 33.5°C.
Δ R of 1700 = 33.5°C.

$\therefore \frac{33.5}{1700}$ = 0.0197°C/unit change R

$\therefore$ Temp = (R-1577)(0.0197)

See Plot of data points in Figure 2.12.

Channel #2 Motor Voltage

R of 3072 = 25 volts
R of 2048 = Ø volts
ΔR of 1024

$\therefore \frac{25}{1024}$ = 0.244 amp/unit change in R

Table of approximate R vs. volts

R	Volts	R	Volts
2048	0	2969	22.5
2785	18.0	2990	23.0
2805	18.5	3010	23.5
2826	19.0	3031	24.0
2846	19.5	3051	24.5
2867	20.0	3072	25.0
2887	20.5	3092	25.5
2908	21.0	3113	26.0
2928	21.5	3133	26.5
2949	22.0		

Exact voltage:

$(R - 2048)\ \frac{25}{1024}$ or 0.0244(R) - 50

See Figure 2.13.

Channel #3 Motor Current

Sensed IR drop through a resistor
a one volt IR drop $\simeq$ 9 amps
Zero volts recorded as R of 2048
+1 volt is recorded as R of 2457.6 representing 9 amps
or 9 amp change = ΔR of 409.6

$\therefore \frac{9}{409.6}$ = amp/unit change in R

$\therefore$ Total motor current = $\underline{R-2048}$ (0.22)

R	motor current amps	R	motor current amps
2048	0	2298	5.5
2093.5	1	2321	6.0
2139	2	2344	6.5
2162	2.5	2367	7.0
2185	3.0	2389	7.5
2207	3.5	2412	8.0
2230	4.0	2435	8.5
2253	4.5	2457	9.0
2275	5.0	2480	9.5

See Figure 2.14.

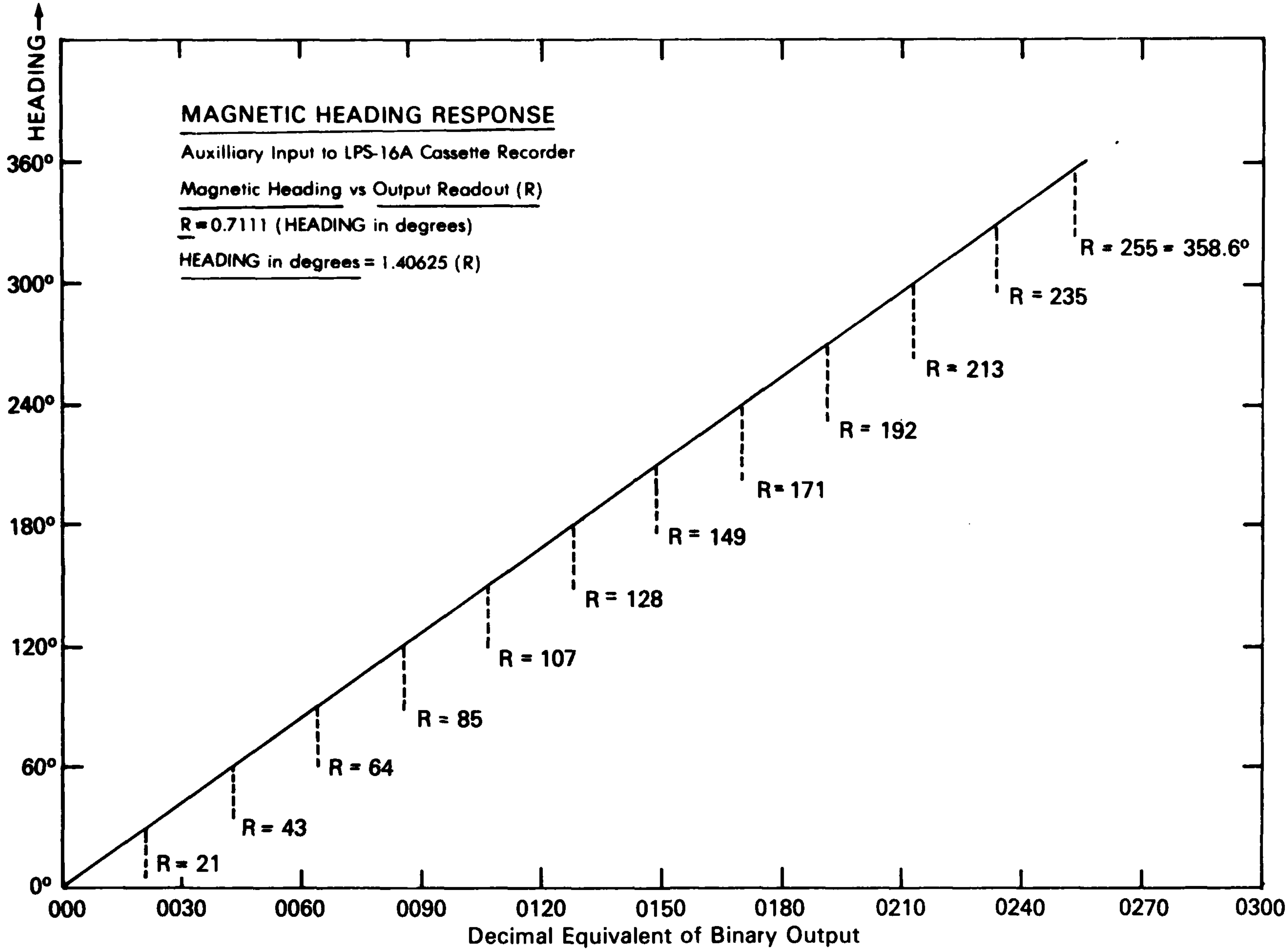


Figure 2.10 Magnetic Heading Sensor Data

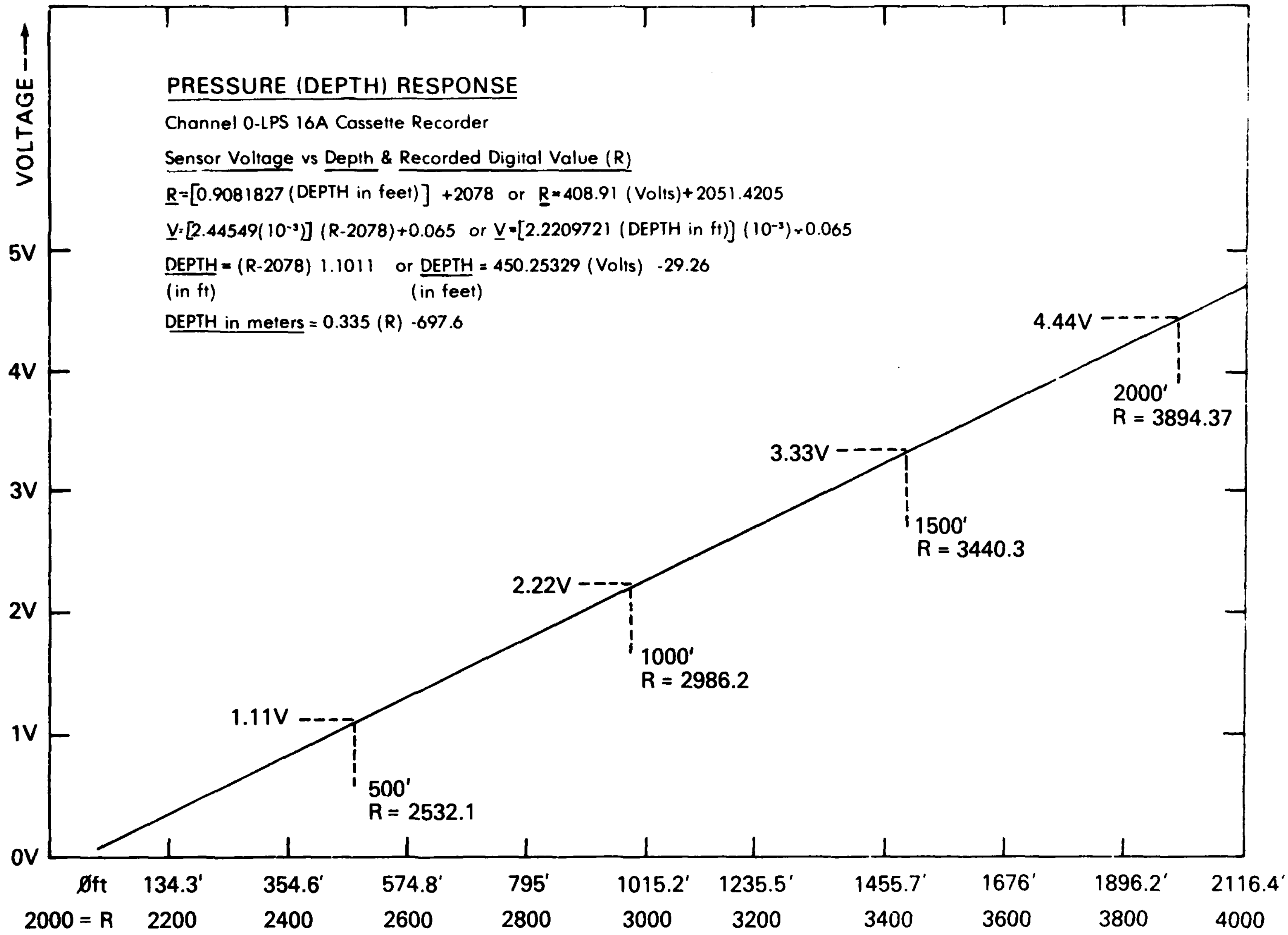


Figure 2.11 Pressure (Depth) Sensor Data

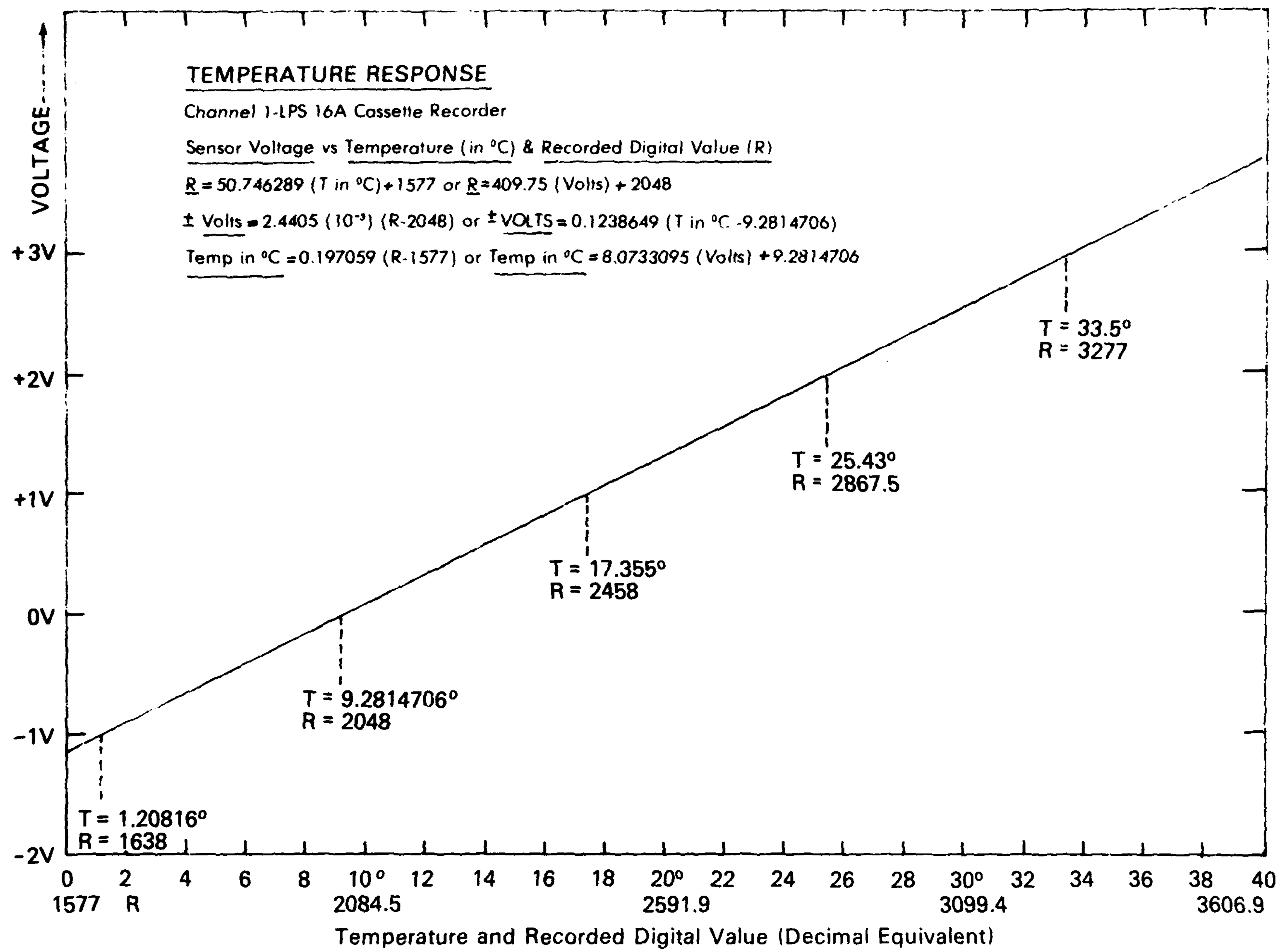


Figure 2.12 Temperature Sensor Data

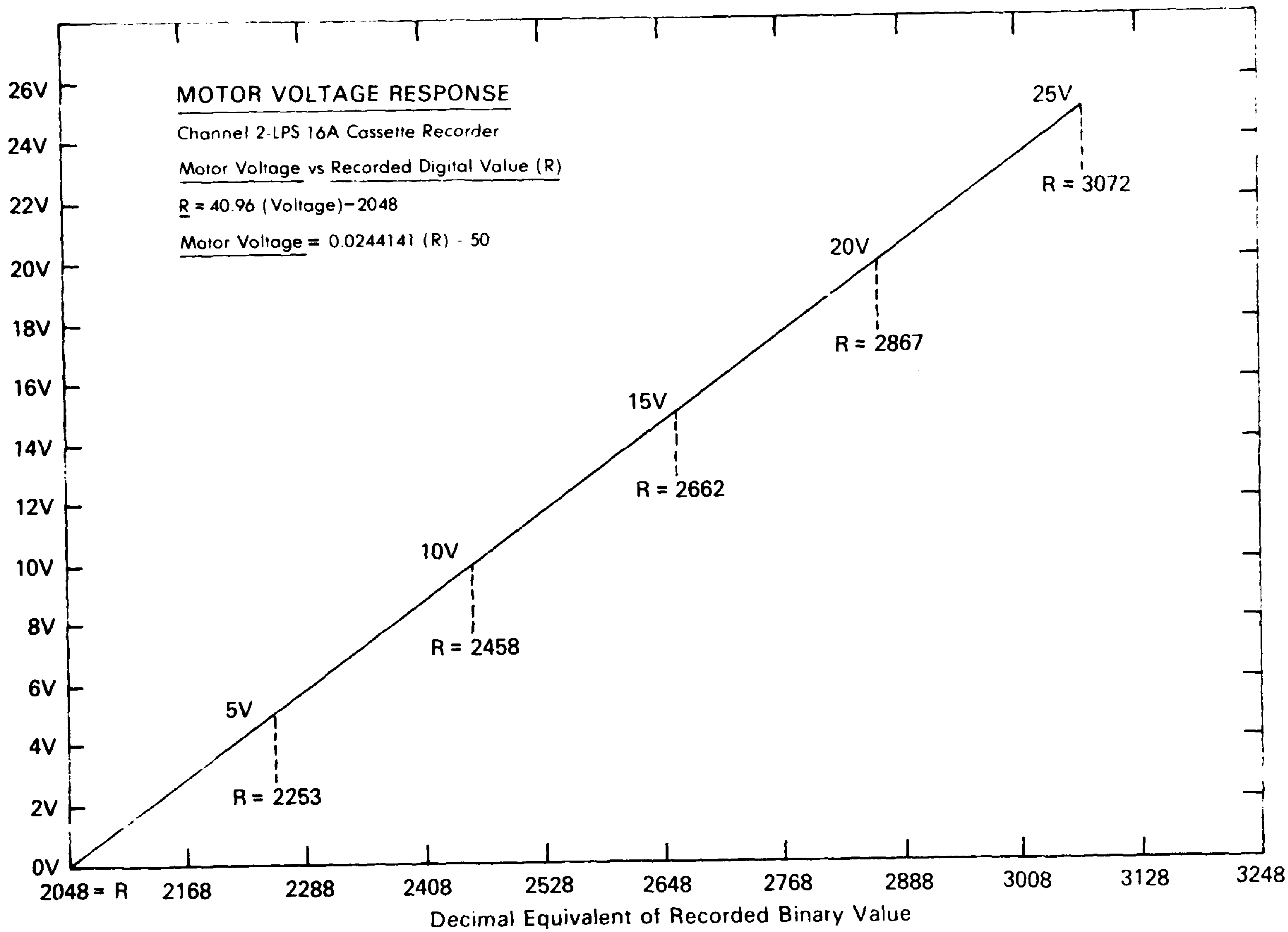


Figure 2.13 Motor Voltage Data

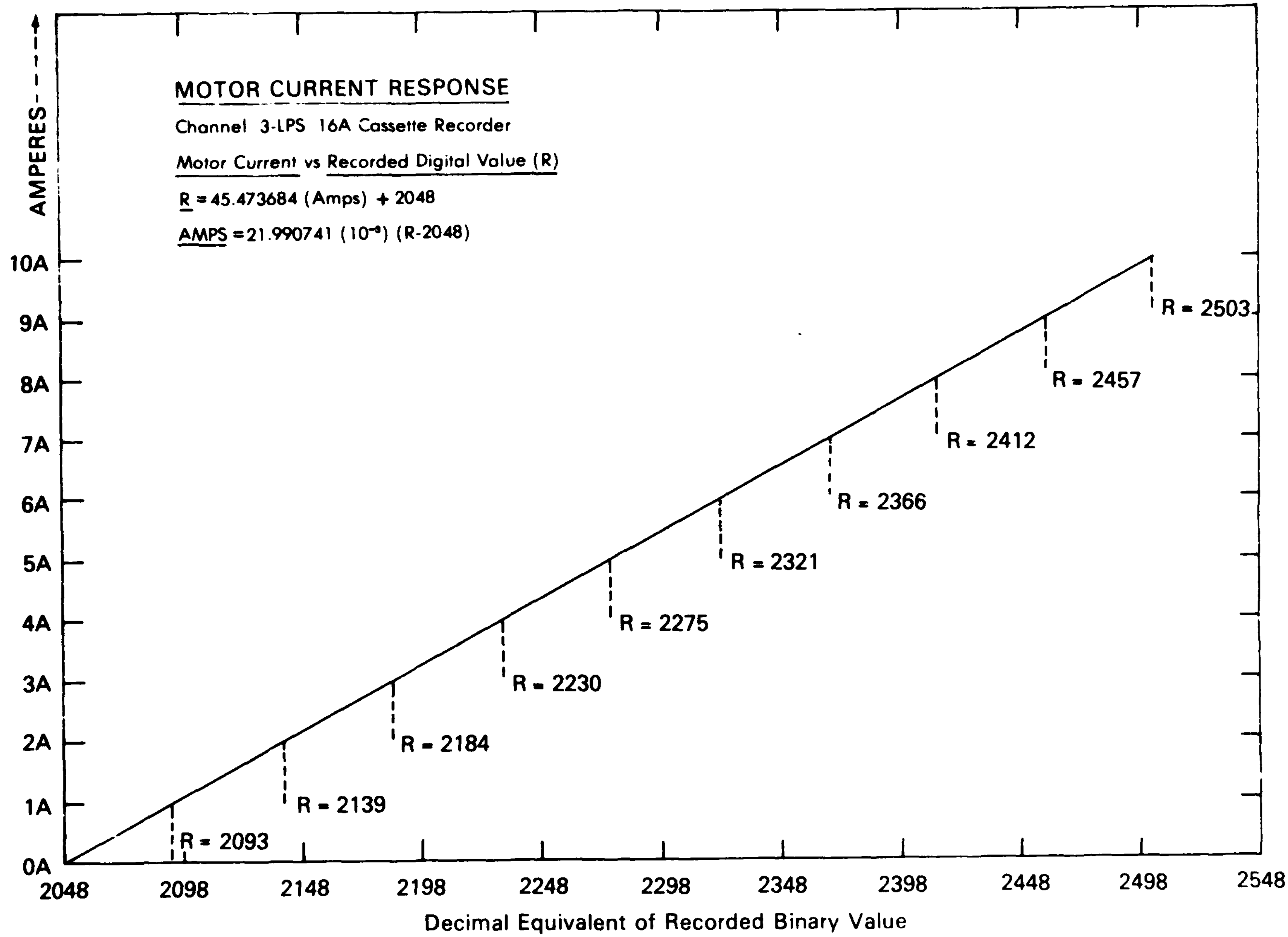


Figure 2.14 Motor Current Data

3.0 SYSTEM OPERATION

The Vertical Profiler (VP) was designed to withstand the abuse that normally accompanies electromechanical equipment used below the ocean surface. Because of its heavy-duty construction, it takes four men to launch the VP. Careful planning and checking throughout the deployment operation are necessary in order to prevent human and/or equipment damage and wasted effort. The information that follows is provided for the VP user to use as a basis for VP operational preparation. A fundamental schedule for preparing the VP for use can be programmed in two parts;

(1) Laboratory preparation.
(2) Field or predeployment preparation

3.1 LABORATORY PREPARATION

Laboratory preparation involves conditioning the VP for launch at its home base or place of storage. Here are some suggestions for laboratory preparations:

(1) Use at least two people to move the VP about, if necessary.
(2) Be sure the VP Test Stand (see Fig. 3.1) is available and capable of supporting the VP.
(3) Try to work in a well-lighted and spacious area, if possible.
(4) Have standard technician tools and test equipment available (voltmeter, oscilloscope, pliers, screwdrivers, wrenches, etc.).
(5) Oil may be spilled, so have rags and a catch-pan available.

CAUTION! When working on the VP in a vertical or horizontal position, ensure that the VP is secured and is not positioned to cause injury. The movable spheres can easily smash fingers or skin knuckles. Furthermore, the VP is some what top-heavy when standing upright, so BE CAREFUL AT ALL TIMES!

3.1.1 Major Structural Components

The VP consists of the

(1) Main-frame structure (fiberglass framework supporting the spheres and the flotation block).
(2) Lower sphere (Buoyancy Control Housing).
(3) Upper sphere (Main Control/Recorder Housing).

3.1.2 Main-Frame Structure Checklist

(1) Check fiberglass structure for cracks or damage.
(2) Tighten any loose nuts/bolts that hold the structure together.
(3) Check sphere pivot bolts.
(4) Check flotation block bolts.
(5) Check tether tie-hooks (2) and their associated nuts.

The remainder of the checkout involves both spheres. The total system should be checked completely, actually simulating a complete "Cycle Duration." To simulate a complete descent/ascent cycle, the VP must be supported horizontally on the VP test stand as shown in Figure 3.1.

3.1.3 Lower Sphere Checklist (Buoyancy Control Housing)

(1) With the sphere axis set vertically (external bladder housing hanging toward floor; battery pack and electronics upward), remove the upper hemisphere.

(2) Remove the external bladder protective housing. (Do not remove the bladder.)

(3) Inspect the main battery assembly, which should neatly be packed around the circumference of the lower hemisphere. There should be 20 individual lithium

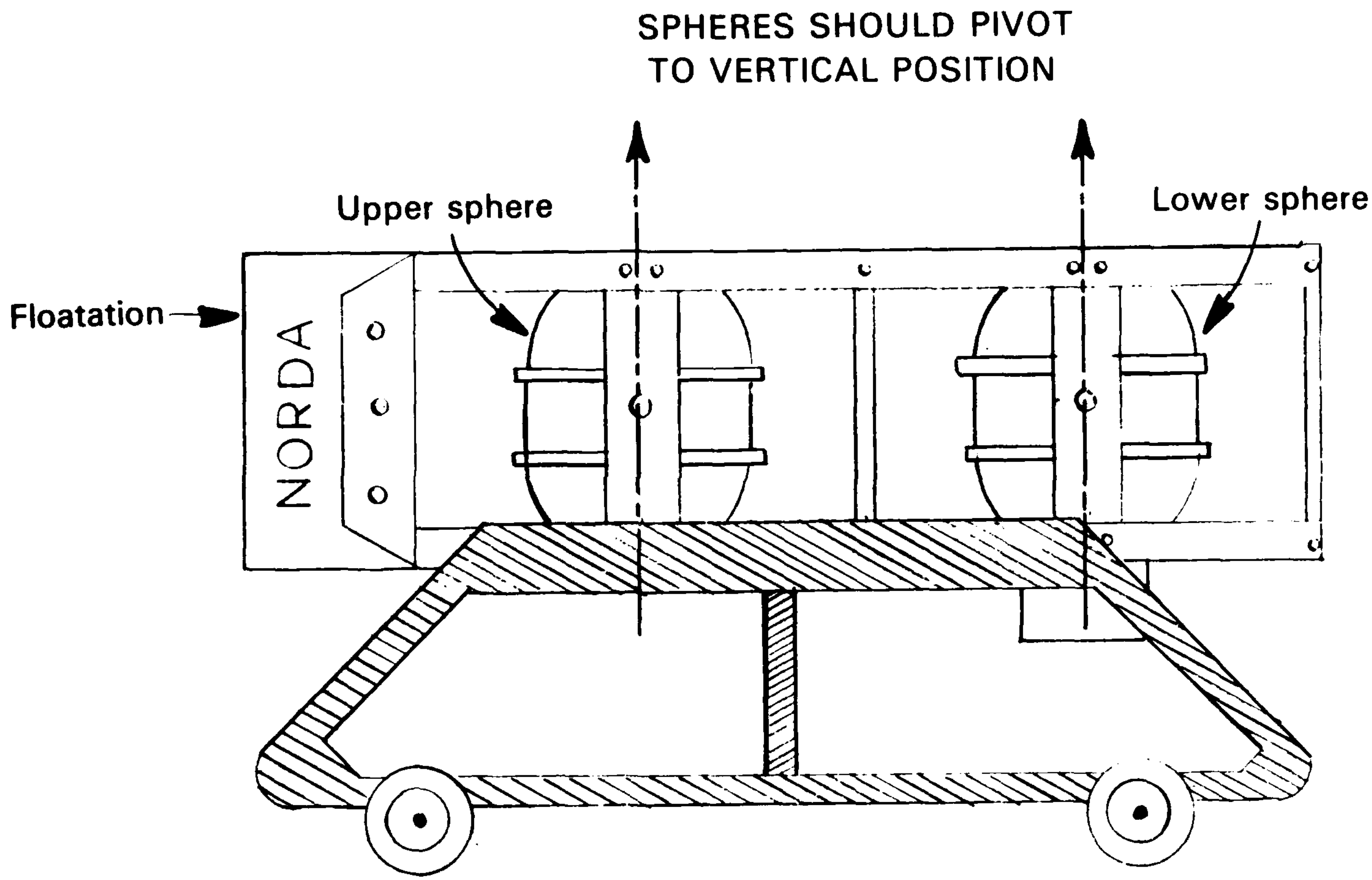


Figure 3.1 Vertical Profiler on Its Test Stand

cells arranged into four 5-cell packs, each 5-cell pack producing 12 V and 5 Ah at a 5A drain. However, each 5-cell pack should be capable of producing a minimum of 4.5 amperes of current flow with a voltage between 11 and 13 volts. To check a particular cell pack, disconnect the cell pack from the main battery assembly and use the setup shown in Figure 3.2.

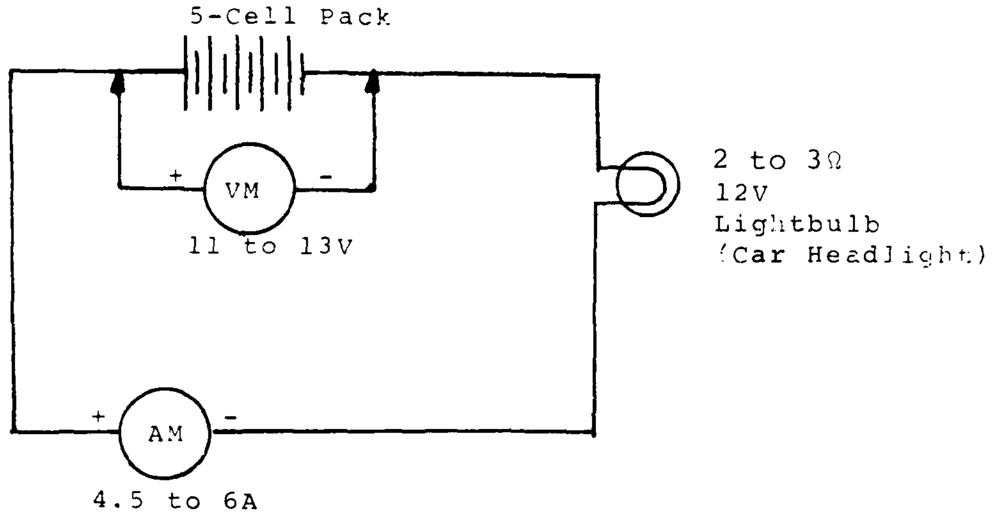


Figure 3.2 Lithium cell pack testing (forming)

If the cell pack does not meet the specifications listed in Figure 3.2, an individual cell may need replacing or the cell pack may need to be "formed." "Forming" is a process used to "burn-in" cells that have been stored for long periods. Long-term storage results in a build-up of internal oxides which cause high internal resistance and prevent the cells from operating at their rated output. To "burn-in" a cell pack, connect the pack as shown in Figure 3.2 and watch the meters for roughly two minutes. If the cell pack needs forming, the voltage and current values should climb to their specified values. If the values do not come up, then one or more cells within the cell pack are defective and need replacing.

(4) After forming or replacing the batteries, be sure the batteries are properly connected and the battery retainer ring is secured. (Double check the terminal connections.)

(5) Check the battery control relay for a good connection.

(6) Be sure the electronic control circuit board is properly secured.

(7) Check any plugs for a loose connection or broken wires.

(8) Insure the external bulkhead connector is properly installed.

(9) Be sure the penetration seals around the equator of the sphere are secured.

(10) Keep the main power switch "off" for now.

3.1.4 Upper Sphere Checklist (Main Control/Recorder Housing)

(1) With the sphere axis set vertically (Fig. 3.1), remove the upper hemisphere. NOTE! The pressure transducer is located at the top of the sphere, and a cable connects the transducer to the main electronic chassis inside the sphere. The cable may or may not be connected to the upper hemisphere, depending upon how

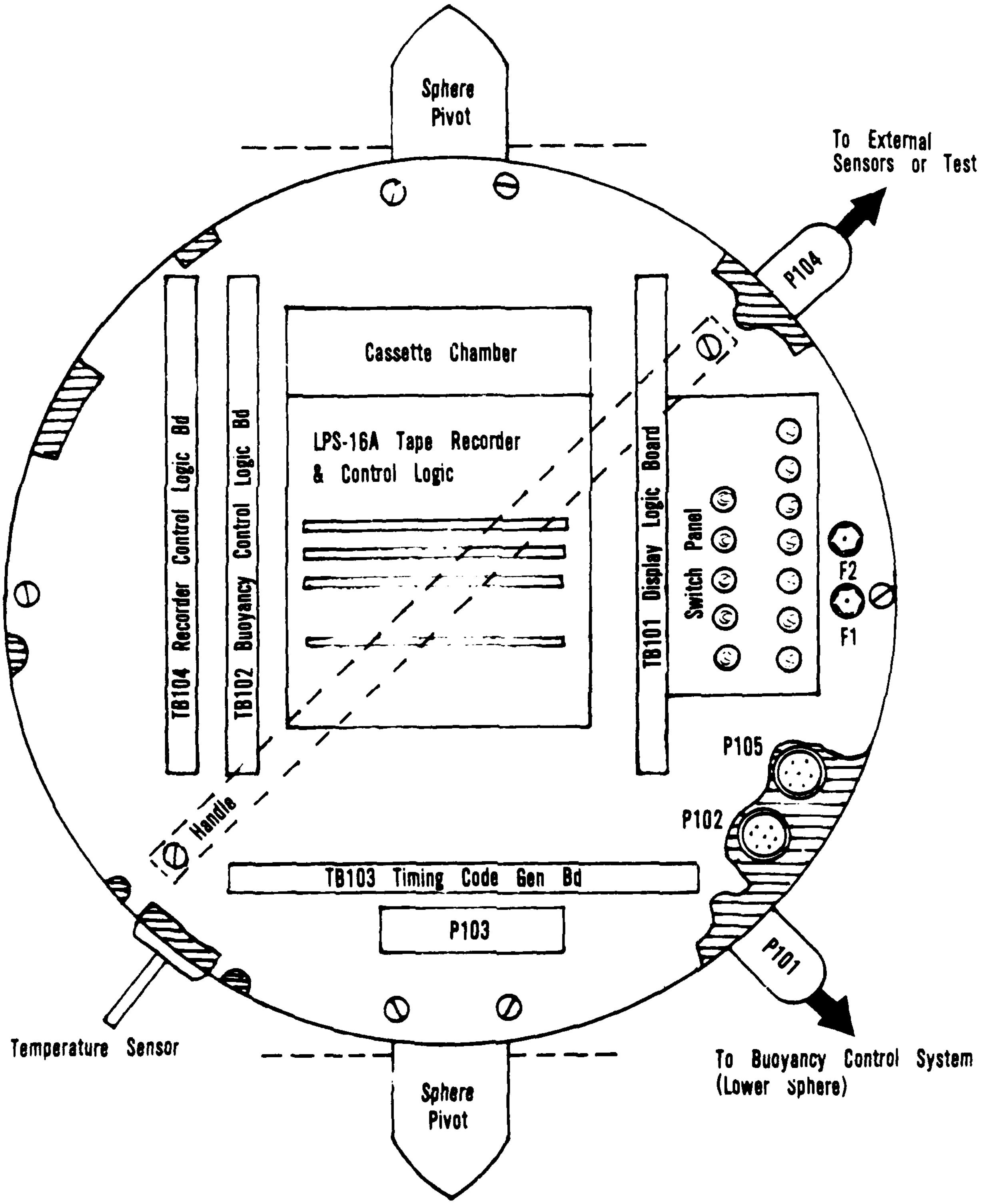


Figure 3.3 Top View of chassis in the upper sphere (Main Control/Recorder Housing)

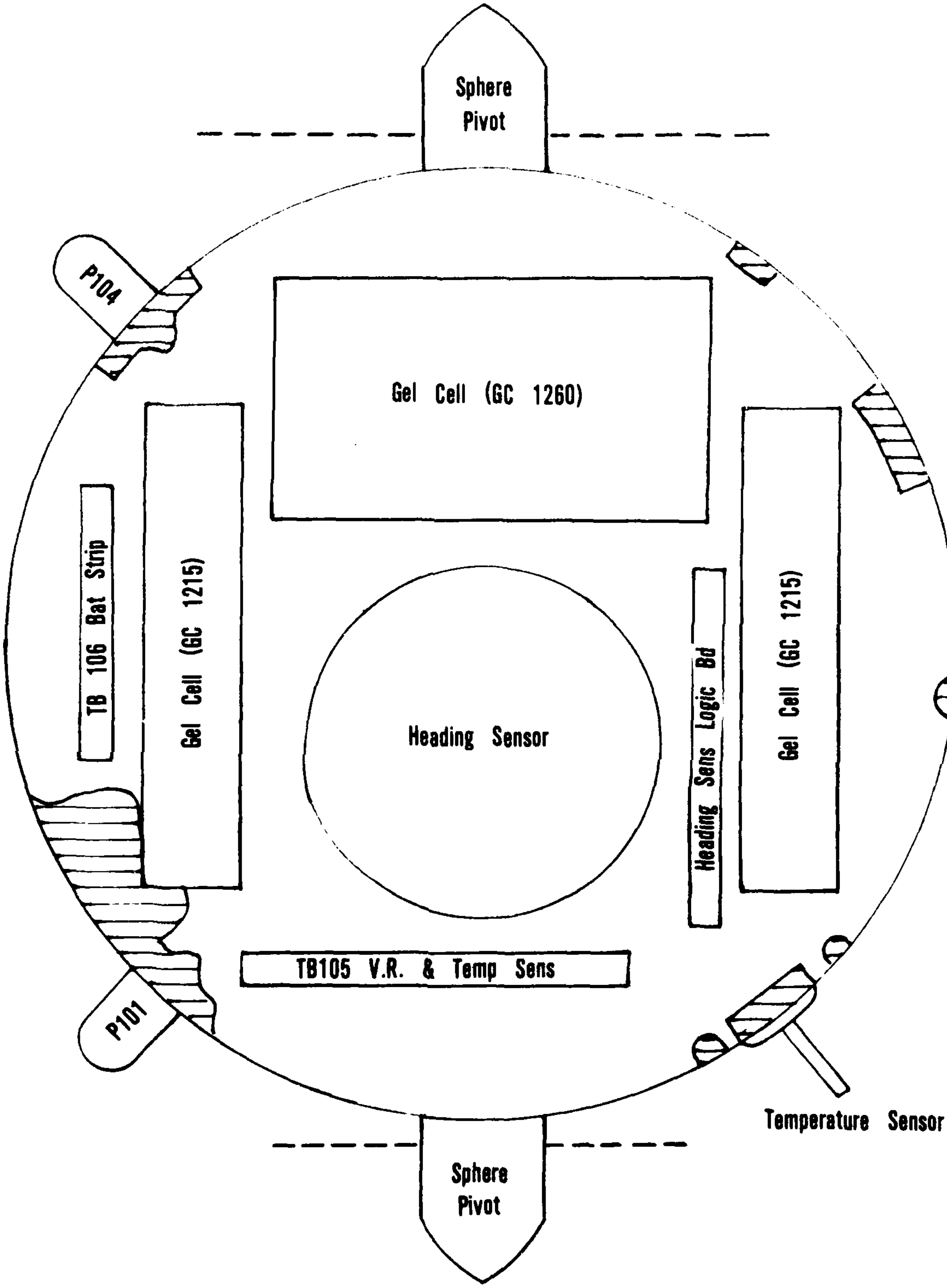
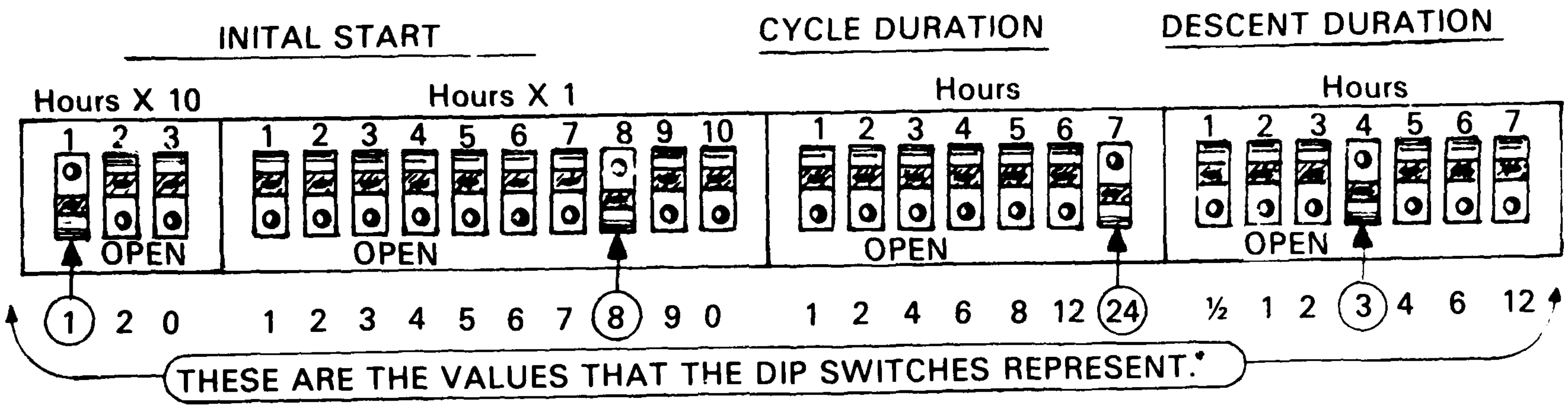


Figure 3.4 Bottom view of chassis in the upper sphere
(main Control/Recorder Housing)



<u>CYCLE DURATION:</u> (Length of time for one descent/ascent cycle and is measured from "valves open" to next "valves open.") <u>24 hrs</u>

<u>DESCENT DURATION:</u> (Length of time the VP is submerged and is measured from "valves open" to "start pump" of same cycle.) <u>3 hrs</u>

To summarize the switch settings above, the VP has been programmed to start its first descent at 1800 hrs, stay submerged for 3 hrs, and start its next cycle at 1800 hrs the following day. Note: If the CYCLE DURATION had been for 8 hrs, then the following cycle would have been 8 hours later, or at 0200 hrs, then another cycle would follow at 1000, etc.

* BE CAREFUL <u>NOT</u> TO USE THE WHITE ENGRAVED NUMBERS AS THE SWITCH VALUES!

BE CAREFUL <u>NOT</u> TO USE MORE THAN 1 SWITCH FOR EACH MAJOR PROGRAMMABLE ITEM! (for example, do not attempt to select a 5 hr cycle duration by using switches 4 & 1. A 5 hr cycle duration is not selectable; you must choose between 4 & 6.)

Figure 3.5 Display and switch panel arrangement

the last user left it. If it is connected, carefully disconnect the plug from the pressure sensor at the dome of the hemisphere, and let the cable hang free of the sphere. If the cable is not connected to the upper hemisphere, it should be found within the lower housing.

(2) Refer to Figures 3.3, 3.4, and 3.5 for the following steps in the checklist, which involve removing the complete internal chassis. However, before removing the chassis, locate the components shown in Figure 3.3 on the physical chassis.

(3) Begin removing the chassis by disconnecting P105 and P102.

(4) Remove the six flathead screws around the circumference of the chassis. (A long grasping tool or magnetic screwdriver is handy here.)

(5) Carefully lift the chassis straight, while watching for wayward wires becoming caught.

(6) Set the chassis on a flat surface and prop up one side in order to have it sitting upright. (Be careful not to loosen the Heading Sensor card under the main chassis plate. It can cause shorting problems if not properly seated.)

(7) With the chassis sitting securely out of the housing, some basic checks can be made. The first check is to ensure that there is a good charge on the three rechargeable batteries located under the main chassis plate. (See Fig. 3.4 for the location of the Gel Cells (3).) A quick way to determine the "health" of the batteries is to use the switch panel on the main chassis (see Fig. 3.5). Begin the battery check by having all the switches in the "off" position (down).

(8) Turn on the "Power On" and "Display Power" switches. All the digital LED (light-emitting diode) displays should light. If they do not, or if they appear dim, the batteries need immediate charging. If they appear bright, battery charging must still be accomplished, but it can be done later after the tests. The following paragraph (9) is the battery charging procedure.

(9) Charging the batteries: Below the center main chassis plate locate the battery terminal strip TB106 (see Fig. 3.4). It has -12V, COM, +12V, and +24V terminal screws labeled. It is to this terminal strip that power is applied to charge the batteries.

The batteries can be charged either together or individually. When they are charged together, a 40 VDC source is needed (Fig. 3.6) and the charge time may be as long as two days. Charging the batteries individually requires only a 14 VDC source and may require only one day to charge the three batteries.

METHOD 1: Charging All Three Gel-Cells With a 40 VDC Source

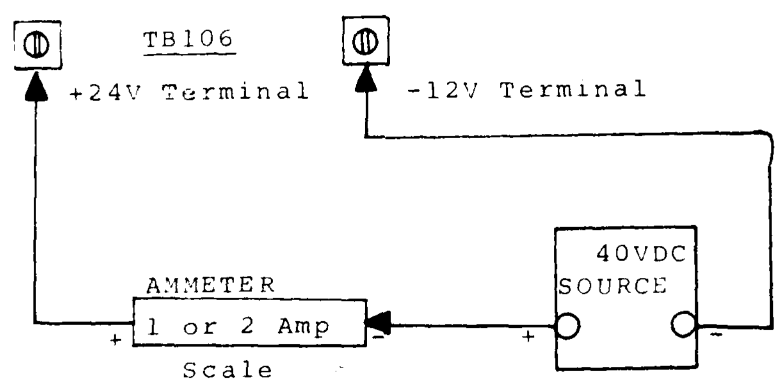
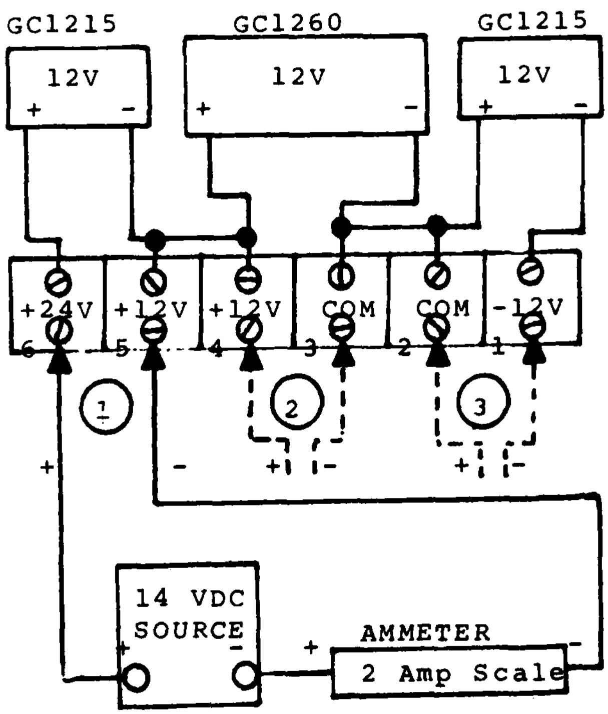


Figure 3.6 Set up for charging all cells at once

Connect the power supply(s)* and the ammeter (1 or 2 amp scale) to the terminals as shown. Slowly raise the voltage to 40 VDC (it can be monitored with a precise voltmeter, if desired) and observe the ammeter. If the batteries are weak, the current may be only 100 or 200 milliamps initially, but after a few minutes it may rise. It has been found that a waiting period of about 10 to 15 minutes after the power supply has been turned on tends to indicate the "state of health" of the batteries. If, after this period, the current is still rising and is between 100 and 200 milliamps, the batteries need overnight charging. If, however, the current is less than 100 milliamps and is stable or dropping, the batteries are well-charged. Nevertheless, it is wise to let them charge at least 24 hours. It has been found that after a full charge, the current levels off at around 20 to 30 milliamps (assuming a 40 VDC source).

To charge the batteries individually, a 14 VDC/2 amp source is used, (Fig. 3.7) while monitoring with an ammeter set on the 2 ampere scale. Charging currents will be higher than with Method 1, possibly around 500 milliamps on GC1260, or even higher, depending on the charge. The smaller GC1215 batteries should produce significantly lower currents, 50 to 200 milliamps. Each battery is charged separately using the above diagram as a guide (the order of charging is not important). After the voltage has been applied to a battery, current may slowly rise, level off, then slowly decrease as it charges. When the current drops below 50 milliamps, or stabilizes at some level for a period of minutes, then the battery is charged. This method of charging should be faster than Method 1 because of the lower charging resistance.
NOTE: Always charge (Method 1 or 2) with the power turned off on the switch panel.

METHOD 2: Charging the Individual Gel-Cell Batteries



TB106
Located just under the fuseholders on the main chassis plate.

Figure 3.7 Charging individual cells with a 14VDC source.

* If a 40 VDC/0.5 amp source is difficult to locate, two 20 VDC/0.5 amp sources, in series, can be used (other combinations are also possible).

If the batteries are charged, the upper sphere checkout can be continued. (Turn on the "Power On" and "Display Power" switches.)

(10) Turn on the "Reset" switch momentarily. All LED's should be lit and read "[illegible]."

(11) Turn on the "Start" switch. The right (least significant digit) LED should start increasing its count at a one-second rate.

(12) Turn on the "Fast Time" switch. The counting rate should greatly increase (100 times faster).

(13) Turn off the "Fast Time" switch. The counting rate should return to normal (one-second rate).

(14) Turn on the "Stop Time" switch. The count should remain constant.

(15) Turn off the "Stop Time" switch. The count should resume at a one-second rate.

(16) Activate momentarily, "Reset." The count should return to zero.

(17) Activate momentarily, "Valve Open." The red LED to the right of the "Valve Open" switch should light.

(18) Activate momentarily, "Valve Close." The light should go off.

(19) Observe the data logger cassette holder. There may or may not be a magnetic tape cassette in the holder. If there is tape, depress the release button and remove the cassette from the top (it does not open very wide).

(20) If there is no tape or if you have just removed a cassette, insert a fresh cassette (Phillips Standard Cassette or equivalent). The empty reel of the cassette should be on the left side with the recording tape exposed on the top when the cassette is inserted. Close the Cassette Recorder Door.

(21) Activate and hold the "Load Forward" switch and watch the left reel of the cassette through the holder window. It should turn very slowly in a counter-clockwise direction. Keep the "Load Forward" switch activated until the transparent tape leader is wound on the left reel and the brown magnetic tape is observed starting to wind onto the reel.

(22) Release the "Load Forward" Switch.

Notice the "Record Inhibit" switch. This switch can be used to disable the sensors and the recording of data onto the tape. However, if it is activated, it does NOT inhibit the movement of tape as described in step (21), only the recording. An example of where it can be used is "Load Forward" operations or the predeployment test, where most of the electronic systems are checked. It is advisable, however, to keep this switch OFF for this checkout, even though the sensor data is useless. Time data will still be recorded and used to check out the recording capability of the data logger. The sensor channels can be checked for proper recording by applying appropriate analog input voltages to each sensor recording channel and decoding the recorded tape for verification. This is discussed further in the data analysis section of the manual. Keep in mind, however, after recording test samples in the data logger, a fresh tape cartridge must be inserted prior to deployment.

(23) Turn all the switches on the switch panel to the off, or down, position.

At this point, all switches except the "Pump On/Off" switches have been checked.

(24) Setting the Overdepth Circuit. With the main control chassis still out of the upper sphere, locate circuit card TB105 (refer to Fig. 3.4). The purpose of the overdepth circuit is to cause the hydraulic pump to turn on at a predetermined depth in the event the tether should break or if the VP should sink to a potentially damaging depth for the VP or its sensors. When the pump turns on, the external bladder is filled, positive buoyancy is achieved, and it rises to the surface. After the VP comes to the surface, there are no subsequent descent/ascent cycles. All prior programming is terminated.

To carry out the overdepth adjustment procedure refer to the logic diagram of RECORDER INPUTS AND CONTROLS-BC1224A, the card TB105. Also locate amplifier A4 on the logic diagram. On A4, pin 3, is the overdepth circuit as shown in Fig. 3.8.

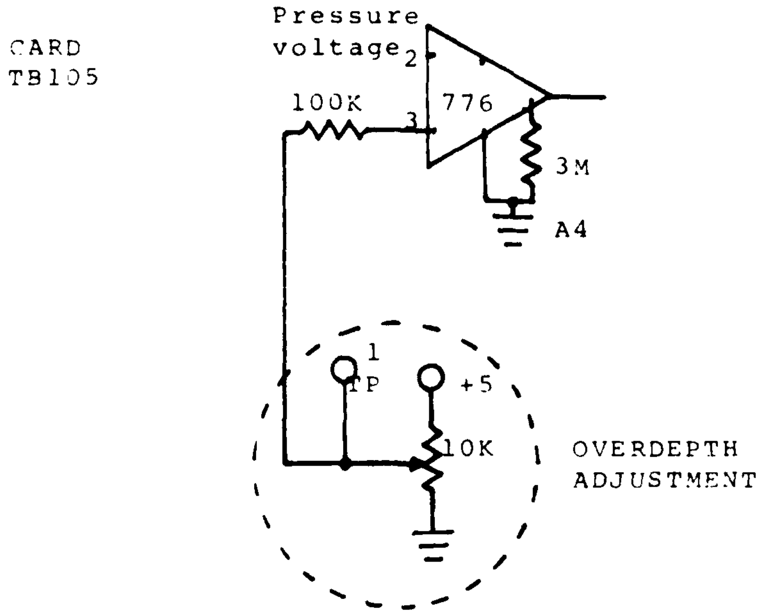


Figure 3.8 Overdepth adjustment

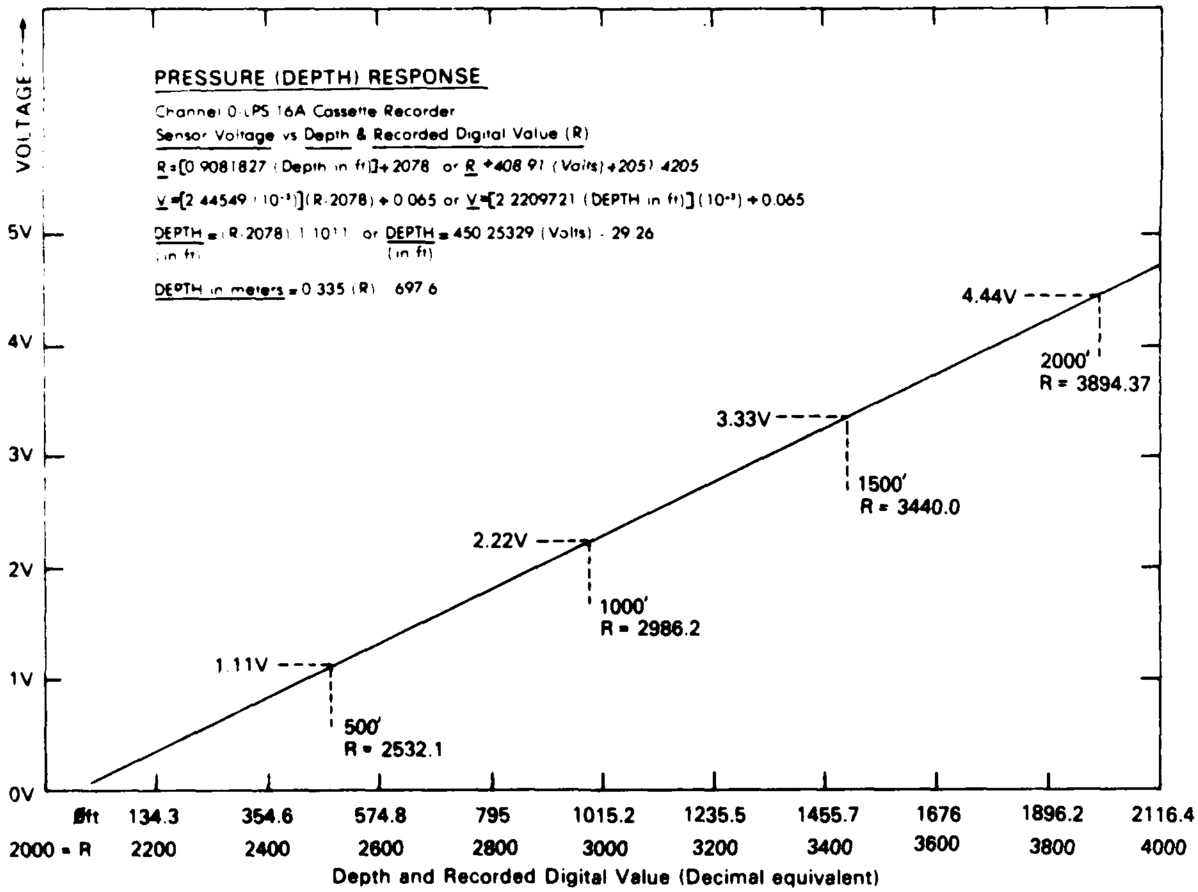


Figure 3.9 Pressure (Depth) Response Data

Locate the overdepth variable resistor and test point (TP1) on card TB105. Have a precision voltmeter available to check the voltage at this test point.

For the adjustment of the resistor, system power must be applied and the voltage at TP1 observed with the voltmeter. The amount of voltage required depends upon the maximum depth considered dangerous for the VP's configuration. According to the diving characteristics (stated in section 1.3, Diving Characteristics), the conductivity/temperature sensor can sustain a maximum depth of 1000 feet (304 m). If the VP were configured with the conductivity/temperature sensor, 1000 feet should be considered the maximum depth for this adjustment procedure. The voltage which corresponds to this depth can be found using the graph in Figure 3.9. According to this graph, the pressure transducer produces 2.22V at a depth of 1000 feet. Referring back to the logic diagram of TB105, when amp A4 gets this voltage from the transducer, it will compare it with the voltage from the overdepth circuit (the 10 K Ω potentiometer setting). If they are equal, the hydraulic pump is turned on. In this case, using 1000 feet as our maximum depth, the voltage should be set to 2.2V (2.1V would provide a measure of safety). The procedure, then, is to monitor TP1 with the voltmeter while adjusting the 10 K Ω potentiometer shown in Figure 3.8, or on the manufacturer's RECORDER INPUTS AND CONTROLS diagram for 2.1 — 2.2V.

If, however, a different depth is to be considered, a formula to use to determine the voltage for that depth is as follows:

$$\text{Voltage Setting} = 2.220972(10^{-3})F_d + 0.065$$

where F_d is depth in feet

Example: Assume 850 feet to be the maximum depth.
To determine the voltage at TP1, use the previous formula:

$$2.220972(10^{-3})\ (850) + 0.065 = \underline{1.953 \text{ volts}}$$

This completes the overdepth setting.

(25) Chassis installation. Before installation ensure that the batteries are charged. Install the chassis back into the upper sphere while being extremely careful not to dislocate circuit cards and snag or pinch wires. The chassis will seat easily if it is inserted with the cutouts situated properly. Be sure that all six screws are secure.

(26) Recheck chassis installation. (Do not install upper hemisphere!)

(27) Be sure that the recorder connectors are secured.

(28) Check all visible plugs for a good connection: P102, P103, P105, and P106.

(29) Secure the two external bulkhead connectors.

(30) Check the penetration seals around the equator of the sphere.

(31) Recheck the operation of the control unit by repeating steps (10) through (23) after turning on power and display power.

(32) Be sure that all switches are off on the control panel.

At this time, the VP checkout procedure has progressed thus far:

(a) The top hemisphere covers are still removed (both).

(b) The external bladder of the lower sphere is exposed.

(c) The power packs in the lower sphere are formed and are ready to produce the necessary hydraulic pump power.

(d) The Gel Cells in the upper sphere are charged.

(e) A new tape is installed in the data logger.

To continue the laboratory preparation, the VP must be programmed and observed going through complete ascent/descent cycles or "cycle durations." This involves both spheres.

3.1.5 Complete Buoyancy System Test

The procedure for checking the Buoyancy Control System (lower sphere) and the Main Control logic (upper sphere) working together is as follows:*

(1) Have available the following figures and diagrams for component location, or possible troubleshooting:

Figure 3.3 Upper Sphere Chassis Layout
Figure 3.5 Switch Panel & Display
Figure 3.10 TB102 DIP Switch Settings
Figure 3.11 Emptying the External Bladder
Figure 2.4 Buoyancy Control Housing (Electrical)
Drawing 1850-1. Time Code Generator-Timing Board
Drawing C-BC-1225. Timing Unit & Display
Drawing BC-1223. Buoyancy Control System TB102
Drawing BC-1224. Recorder Inputs & Controls

(2) Find circuit card TB102 in the Main Control/ Recorder Housing (upper sphere). Locate the programming DIP switches labeled "Initial Start," "Cycle Duration," and "Descent Duration." Refer to Figure 3.10 for a description of the switches.

(3) Using Figure 3.10 as a guide, set the switches for the following programmed times:

HRS X 10	HRS X1	CYCLE DURATION	DESCENT DURATION
0	1	1	1/2

(4) Using Figure 3.3, if necessary, locate circuit card TB104. Find the switches used to program the data logger recording intervals which are labeled "10 SEC," "30 SEC," "1 MIN," and "2 MIN."

(5) Set the switches for 10 seconds.

(6) Turn on power and display switches to the Main Control/Recorder Housing (upper sphere).

(7) Turn on power to the Buoyancy Control Housing (lower sphere).

(8) On the upper sphere switch panel, activate "Reset." The pump should turn on.

(9) Using the "Pump Off" switch, interrupt the pump operation by turning off the pump.

(10) Using the "Pump On" switch, turn on the pump again. Let the pump run until it fills the external bladder and shuts off automatically or a maximum of 5 minutes if sump switch fails. (There is a "Sump Empty" switch which is located on the internal sump. Electrically, it can be found on Figure 2.4. The "Sump Empty" switch initiates the automatic turning off of the pump.) If everything worked well, the

(a) pump should be off,
(b) external bladder should have fluid in it,
(c) "Valve Open" LED should be off (descent valves closed), and
(d) the display should be indicating all zeroes.

The last ten-step procedure has verified that the pump and its associated logic operates properly. The next part checks the actual descent/ascent cycle operation.

*If the Buoyancy Control System develops a leak and loses fluid, refer to the section on maintenance for replacing fluid. The amount of fluid contained in the hydraulic system is critical to proper buoyancy. There should be 4500 ml of hydraulic fluid in the system (4.5 liters or 1.18 gallons).

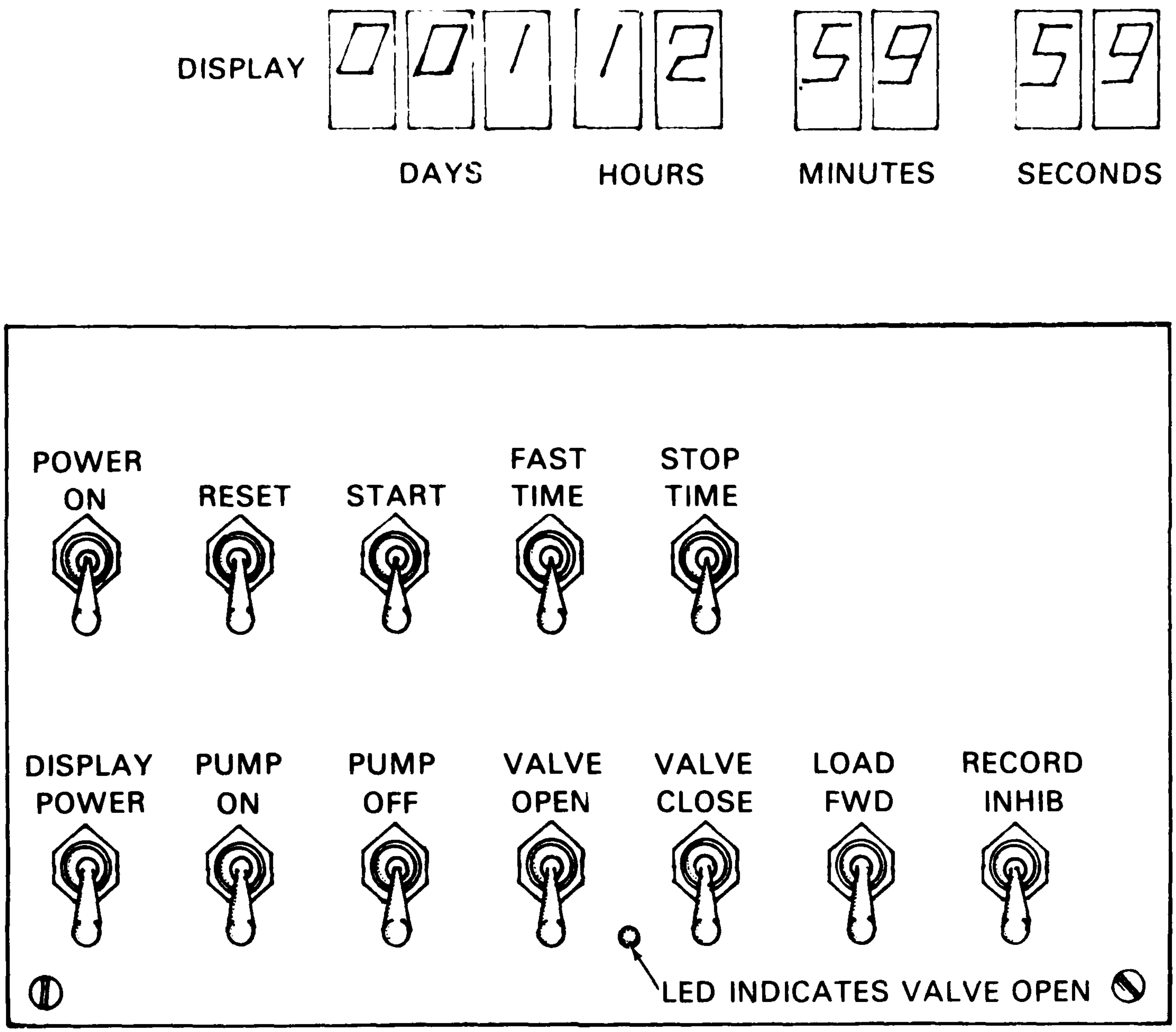


Figure 3.10 TB102 DIP Switch Settings

(11) Activate the "Start" switch. The "seconds" display should upcount. Remember, according to the prior programming in step (3), the initial descent/ascent cycle is not due to start until the display shows the following time:

0 0 0	0 1	0 0	0 0
DAYS	HRS	MIN	SEC

However, the data logger (tape recorder) should be in cyclic operation. According to the programmed switch setting performed in step (4) of "10 SE ," it should be turning on every 10 seconds for a period of roughly one second. Observe this action (or non-action, as the case may be). If the data logger does not appear to be taking up tape at the 10-second interval, the problem may be improper sprocket-to-reel seating of the left take-up reel. If the sprocket is moving, but not the reel, open the tape holder and simply close it again. Do this until the reel properly meshes with the sprocket. If the sprocket does not appear to moving at all, remove the tape cassette completely and watch for sprocket movement. (It could be that the cassette is the problem.) If detailed troubleshooting is needed use the RECORDER INPUTS AND CONTROLS, BC-1224A diagram, as an aid. Once the data logger is operational, the test can be resumed.

(12) Since there is a long waiting period until the descent/ascent cycle is due to start, the "Fast Time" switch can be used to speed up the operation. Be careful when using the switch; it is 100 times faster than normal (e.g., one hour passes in 36 seconds.) Activate the "Fast Time" switch until the approximate reading below is achieved:

0 0 0	0 0	5 7	0 0
DAYS	HRS	MIN	SEC

(13) Be ready to observe the action that should take place at

0 0 0	0 1	0 0	0 0
DAYS	HRS	MIN	SEC

(a) The "Valve Open" LED should light.

(b) The data logger will continue to operate independently of the cycle programming.

(14) Normally, the ambient water pressure would force fluid from the external bladder up into the internal bellows sump, through the now-open valves. It is evident that the bladder needs help. In order to get the fluid from the bladder to the internal sump, pivot the Buoyancy Control Sphere to an upside-down position and, if necessary, squeeze the fluid into the internal sump as indicated in Figure 5.1 (Be careful not to pinch or put undue pressure on the bladder connection to the pipe.

(15) After the bladder is emptied, the LED "Valve Open" indicator should extinguish, indicating the closure of the valves. Put the lower sphere in its bladder-down position again.

(16) The VP has been in a descent cycle since the valves opened at 000 01 00 00. At 000 01 30 00, the pump should start running again. Use the "Fast Time" switch to speed up the clock to about three minutes before the event.

(17) After the pump has filled the external bladder again, it should shut off automatically. (If the VP were in its sea environment, it would now be coming to the surface.)

(18) At a time of 000 02 00 00, the VP would start another descent/ascent cycle, just as in step (13).

(19) This concludes the simulated descent/ascent cycle.

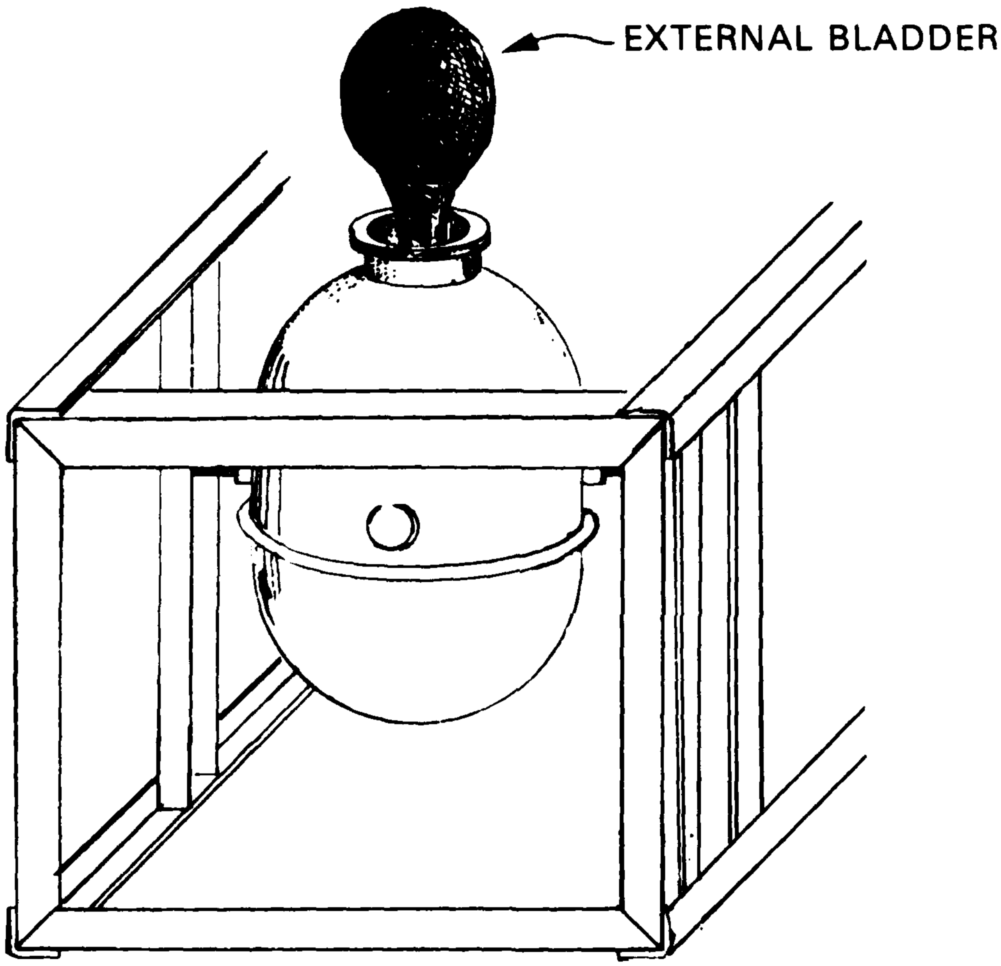


Figure 3.11 Vertical Profiler - Lower Sphere: Emptying the External Bladder

WHEN TESTING IS COMPLETE, BE SURE ALL THE POWER SWITCHES ARE TURNED OFF. IF THE TEST HAS TAKEN 4 TO 6 HOURS OF BATTERY LIFE FROM EITHER SPHERE, IT MAY BE NECESSARY TO CHANGE OR RECHARGE BATTERIES. DO NOT CLOSE UP THE HEMISPHERES YET!!!

3.2 PREDEPLOYMENT PREPARATION

Predeployment preparation includes the following:

(1) Installation of ancillary equipment.
(2) Balancing the Vertical Profiler (VP) in water.
(3) Performing a programmed descent/ascent cycle in water.
(4) Post-test checkout.
(5) Deployment planning.

3.2.1 Installation of Ancillary Equipment

Any equipment that is to be used in conjunction with VP operation must be attached to the VP before balancing the VP in water. This equipment could include the following:

(1) Beacon light.
(2) Telemetry transmitter.
(3) Pinger or sounder.
(4) Additional sensors.
(5) Anything that adds weight to the total VP unit.

Some precautions to observe when installing equipment on or inside the VP are as follows:

(1) Be careful not to damage the basic structure of the VP framework or spheres.

(2) Be sure the attached units are secure and watertight.

(3) Be sure any electrical units have their own power sources.

(4) Be sure that the added equipment does not interfere with normal VP operation.

(5) Try to keep any added equipment to a minimum, since the VP must have buoyancy material added to compensate for added weight.

3.2.2 Balancing the Vertical Profiler (VP) in Water

In order for the VP to operate properly in water, the hydraulic system must provide five pounds of positive buoyancy when the unit is to surface or float, and a negative five pounds of buoyancy to descend or sink. Adding weight will upset this balance. The additional weight can be compensated for, however, by adding a more buoyant material to the VP. A material that is commonly used is called "syntactic foam." One cubic foot of this material weighs roughly 36.75 lb, as compared to one cubic foot of sea water, which weighs roughly 64 lb. When trying to determine how much of this foam to use to compensate for some added weight, this simple rule can be used: For every additional pound added to the VP, 63.4 in^3 of foam should be added. This is roughly the size of a 4 inch cube of syntactic foam. Or, for every cubic inch of foam added, 0.0157722 pounds of buoyancy is added.

On the other hand, if the VP is too buoyant, it is necessary to add weight. The most common method of adding weight purposely is to attach canvas bags to the sides of the VP and fill them as needed with lead shot. The basic procedure for balancing the Vertical Profiler is as follows:

(1) After the lab preparation has been completed and any additional equipment has been added to the VP, use the appropriate control switches to fill the external bladder. (See section 3.1.5 Complete Buoyancy System Test, steps (6) through (8).)

(2) Turn off power to both spheres.

(3) Reinstall

(a) External bladder housing.

(b) Upper sphere cover. (Pressure sensor need NOT be connected.)

(c) Lower sphere cover.

(4) Prepare the VP for transport.

To accomplish the in-water balancing, it will be necessary to locate a pier, dock, water tank, or some place that has the facilities available to simulate the scene in Figure 3.12.

(5) Transport the VP to the test location. (Be sure to bring standard tools and a voltmeter. In addition, an accurate vertical spring scale (fish-weighing scale) is needed, as shown in Fig. 3.12.)

(6) Attach the VP to a hoist arrangement shown, without attaching the scale. Carefully align the VP vertically and lower it into the water. If less than 5 lb of weight were added to the basic VP (i.e., beacon, transmitter, etc.), the VP should be buoyant enough to float. Remember, the external bladder should still be full, which is the maximum buoyancy condition (refer to step 1 of this procedure). If the VP does NOT float, it could be for one of the following reasons:

(a) More than 5 lb of weight was added.

(b) The VP has developed a severe leak and is taking on water. (A leak, large or small, can be detected by watching for an abnormal amount of bubble activity around the VP. Small leaks are more difficult to detect and may require close scrutiny below the water surface by using a large open glass beaker, or some similar viewing device, to penetrate the surface.) If a leak is suspected, immediately return the VP to the surface; let it drain completely; and try to determine the cause of the leak. Seal appropriately.

(c) There is not enough fluid in the external bladder. If the Buoyancy Control System is set up properly, there should be 4500 ml (4.5 liter or 1.188 gal) of fluid in the system. Unless there was a leak in the system during checkout, the correct amount of fluid should be in the system. Another possibility is that the pump did not pump all the fluid from the internal sump to the external bladder. But if the pump shut off automatically when performing step (1) of this procedure, it indicated that the switch and associated logic were operating properly. And finally, the control valves, which let fluid flow from the external bladder to the internal sump when descending, could be in the open position. This would let the fluid that was in the external bladder return to the internal sump after the VP was put into the water. However, it would take a few minutes for this to happen. In any event, if it is suspected that there is not enough fluid in the external bladder, the three possible causes for this failure need to be checked.

(7) If there are no leaks and the VP hydraulic system is filled and operating as it should, but there is more than 5 lb of weight on board, then flotation material must be added. If, however, the VP floats the amount of buoyancy being produced needs to be known and set for a +5 lb.

(8) Adding flotation. Connect the vertical spring scale, as shown in Figure 3.12. While letting the VP sink below the surface, measure the amount of negative buoyancy produced by the VP using the spring scale. The amount of flotation material to be added must produce a buoyancy equal to the absolute value of the negative buoyancy plus 5 lb., or expressed as an equation

$$\begin{array}{c}\text{Amount of buoyancy}\\ \text{to be added to}\\ \text{the VP}\\ \text{(in lb)}\end{array} = \left|\begin{array}{c}\text{Measured}\\ \text{Value of}\\ \text{Negative}\\ \text{Buoyancy}\\ \text{(in lb)}\end{array}\right| +5$$

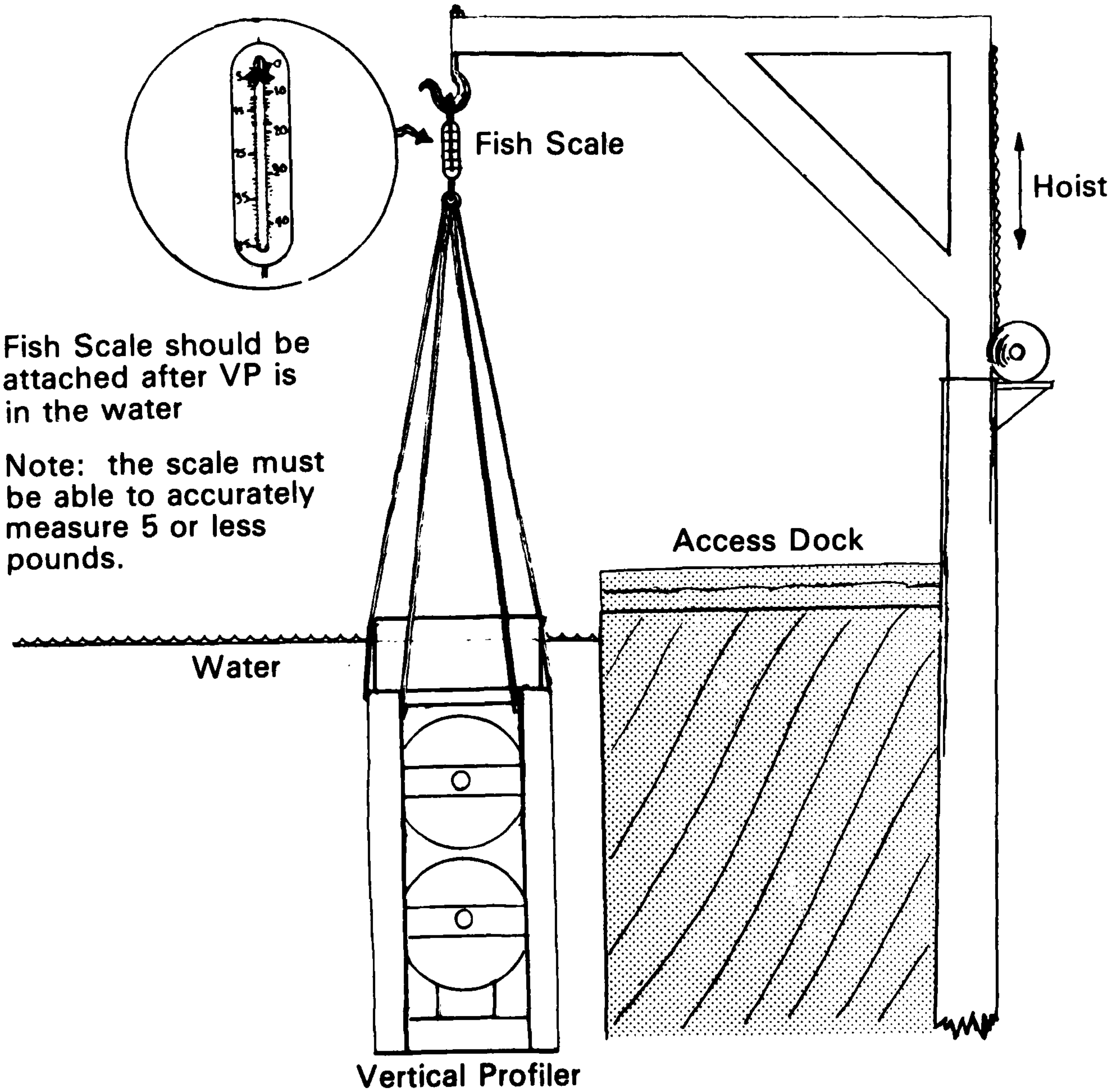


Figure 3.12 Trimming the Vertical Profiler: Initial Setup

EXAMPLE: Assume that the VP sinks, instead of floating. The spring scale is connected as in Figure 3.12 and measures a weight of 2 lb. This means that the VP has a net buoyancy of a -2 lb, or 2 lb of negative buoyancy. The total amount of positive buoyancy that needs to be added is equal to the absolute value of the negative buoyancy plus 5 lb of additional buoyancy, which is what the VP is supposed to have with all the hydraulic fluid in the external bladder, and which equals a total of 7 lb of buoyancy to be added. Now, if syntactic foam is to be used, then the algorithm discussed in section 3.2.2, the opening paragraph, should be used: Add 63.4 cubic inches of syntactic foam for every pound of buoyancy required. So, in this example, approximately 444 cubic inches of syntactic foam is needed. There are many combinations of sizes of blocks of foam that could make up 444 in^3. For example, two blocks of foam 2" X 7" X 16" would make up 448 in^3 and would fit on both sides of the flotation block that is already on the VP (see figure 3.13). The physical arrangement is left up to the user; however, the foam should be distributed evenly around the VP and not lumped all to one side. Another point to be mentioned here is that it is better to have too much buoyancy material than not enough, since more weight can be added later, as in the following step.

(9) Adding weight. If, after step (6), the VP floats instead of sinking, then the VP has positive buoyancy. How much buoyancy, however, must still be

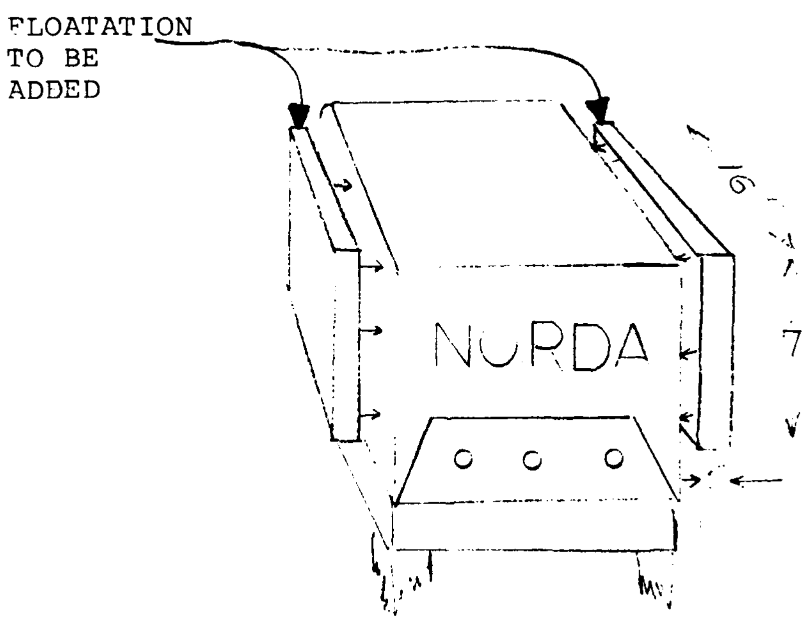


Figure 3.13 Adding syntactic foam to increase buoyancy

determined. The procedure for determining the amount of buoyancy and adjusting it for +5 lb is as follows:

(a) An accurate scale for measuring the weight of lead shot is necessary. The spring scale mentioned earlier can be used by rigging a bag for holding the shot.

(b) Either ample supply of lead shot or some form of dense weighting material must be available.

(c) With the VP loosely tied to the hoist, but still floating in a vertical position, attach weight to the VP in some manner until the VP is barely starting to sink. In other words, try to give the VP neutral buoyancy. In order to do this, weight must be added in small increments until the VP sinks to water level. (For accuracy, it will be necessary to splash water over the top of the VP to help it break the surface tension of the water.)

(d) When it appears that the VP is neutrally buoyant, remove the weight that was added.

(e) Measure the weight of the ballast that was added. If the weight added equaled 5 lb ±1/2 lb, then neither ballast nor flotation has to be added to the VP. If, however, the added weight is less than 4.5 lb, then flotation must be added to produce the 5 lb ±1/2 lb buoyancy required.

EXAMPLE: Assume the added weight was 3 lb instead of the required 5 lb. Then roughly 128 cubic inches of syntactic foam must added to compensate for the needed 2 lb of buoyancy.

On the other hand, if the added weight is more than 5 lb ± 1/2 lb, then the added weight value minus 5 lb is the actual amount of needed ballast.

EXAMPLE: Assume the added weight is 9.5 lb. Then, the amount of lead shot that needs to be added in order to maintain a +5 lb buoyancy is 4.5 lb.

(10) When the VP has correct flotation remove the spring scale, as shown in Figure 3.12, and reconnect the VP to the hoist.

(11) Hoist the VP out of the water, secure it safely on the dock, rinse with fresh water, and let dry.

(12) When possible, remove both sphere covers. Inspect for water leaks. No further testing can be done until the leaks are repaired and the unit is checked out to ensure that no damage has been done to the electronics and that the leaks no longer exist.

3.2.3 Performing a Programmed Descent/Ascent Cycle in Water

Assuming that all power to both spheres is turned off, the procedure for a descent/ascent cycle in water is as follows:

(1) Remove the covers on both spheres, if they have not yet been removed.

(2) Program the DIP switches in the upper sphere on card TB102 (described in Fig. 3.10) for the following setup:

INITIAL START	CYCLE DURATION	DESCENT DURATION
01 hour	01 hour	1/2 hour

(This setup was the same used in section 3.1.5, Complete Buoyancy System Test.)

(3) Program the DIP switches on TB104, Data Logger (Tape Recorder) Recorder Intervals, for "10 Sec." "Record Inhibit" off.

(4) Turn on power to the bottom sphere.

(5) Turn on power and display power to the upper sphere.

(6) Activate "Reset" on the upper sphere switch panel. All display lights should go to zero, and the pump may come on. (The external bladder may still be filled, depending on the previous checkout.) ACTIVATE THE "START" SWITCH.*

*The LED display should start upcounting at a one-second rate. If it does not, activate "Reset" and try again. Also record the time-of-day, since you will want to know when the VP is due to descend.

(7) Turn off ONLY the display power ("Display Power").

(8) Put the covers on both spheres, ensuring that the pressure transducer is plugged in (if there are no problems up to this point). Power is now applied to both spheres.

(9) Using the hoist, return the VP to the water.

(10) The VP should be floating (external bladder should be filled). Allow the harness which connects the VP to the hoist to have between 2 to 3 feet of slack. This will allow the VP to descend only by this amount below the water (see Fig. [illegible]).

(11) Back in step (2) of this procedure, the descent/ascent cycle was scheduled to start one hour (INITIAL START = 01) after the start switch was activated. In step (6) the "Start Switch" was activated. From that time plus one hour, the VP is due to start its descent. Until that time occurs, attach the "fish scale" that was used earlier in the same manner as that shown in Figure 3.12. Wait for the VP to descend.

(12) If the VP does not descend at the approximate time it was scheduled, then there is a problem in the control valve/solenoid system. This must be remedied before continuing.

(13) If everything operates properly, the VP should descend approximately one hour after the "Start Switch" was activated. Because of the harness arrangement, however, it will only descend a few feet, and the VP should be exerting force of 5 lb. This can be measured by reading the scale, which was attached in step (11). If the reading is within ± 1 lb of 5 lbs then the VP can be considered balanced. If, however, the VP exerts more than 6 lb or less than 4 lb, then either floatation material or ballast needs to be added. For example, if the VP exhibits a force upon descent of 8 lb, then roughly 193 cubic inches of syntactic foam needs to be added to compensate for the extra 3 lb of weight. (Normally, if the balancing operation went smoothly, as described in section 3.2.2, this compensation would not be necessary. However, trying to establish neutral buoyancy as in steps (9)c and (9)d may be somewhat arbitrary; therefore, it may necessary to do it again here.)

(14) After the VP has descended, it should stay down for roughly one-half hour (see step (2)). If it stays down much longer than the programmed descent duration, then the pump is not pumping fluid properly to the external bladder. Since the VP is submerged only a feet below the surface and is attached to the hoist via the harness, it can be easily pulled out of the water and analyzed. If everything goes according to the programmed cycle, however, it should return to the surface and stay there for one-half hour (Cycle Duration - Descent Duration = Surface Duration).

(15) If no problems occur, or after all the problems are solved, let the VP go through two complete descent/ascent cycles to ensure reliable operational capability.

This concludes the Programmed Descent/Ascent Cycle.

3.2.4 Post-Test Checkout

After observing the VP go through its cycles, a final post-test checkout must be performed. The basic steps are as follows:

(1) After the descent/ascent cycles have been performed, rinse the VP with fresh water, let it drain dry, and check the spheres for water leaks by removing the covers.

(2) If extensive testing has been performed and it appears that the battery supply may be low, replace or/and recharge them as seems necessary.

(3) Turn off power in both spheres.

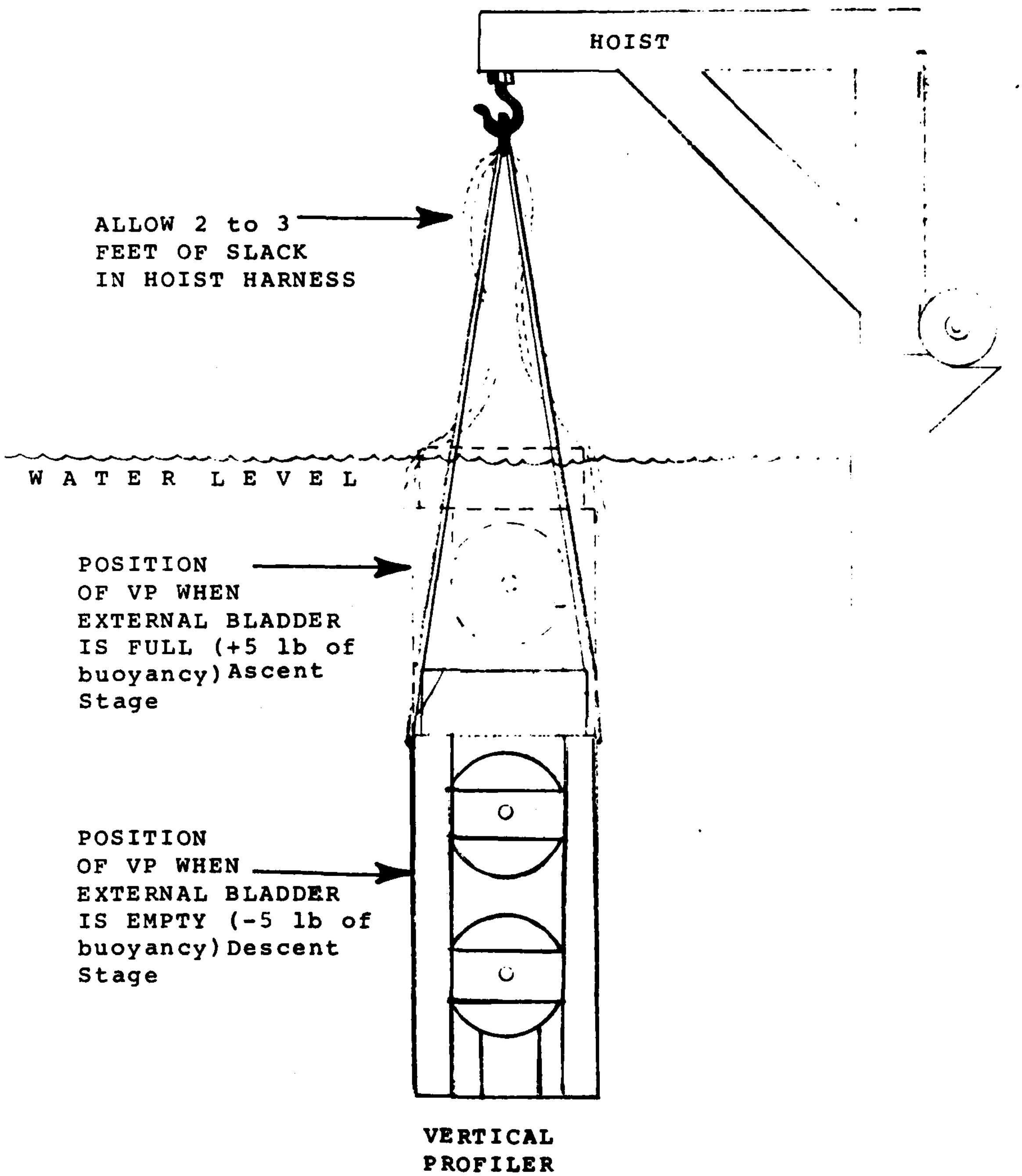


Figure 3.14 Testing the Vertical Profiler descent/ascent cycle in water

(4) Remove data logger tape cassette cartridge and replace with a fresh one (see section on data analysis).

(5) Replace sphere covers and prepare the VP for actual use, which may involve shipping.

3.2.5 Deployment Planning

Before going to sea with the Vertical Profiler, a good plan for deployment aboard ship is necessary:

(1) Be sure arrangements have been made to transport, stow, and deploy the VP from the ship.

(2) Be sure adequate tools, supplies, parts, and personnel are available during the trip.

(3) Finally, with the people involved in actual deployment, methodically go through every step of the operation, while outlining it on paper. Try to anticipate any possible problem that may go wrong and prepare a contingency plan to correct it. Be sure everyone knows their responsibilities. Never assume anything.

4.0 DATA ANALYSIS

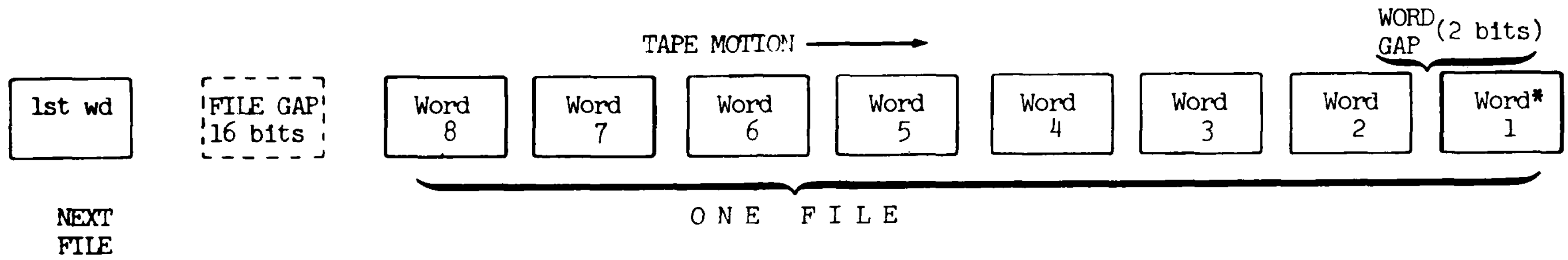
Data gathered by the Vertical Profiler (VP) is stored on a magnetic tape cartridge located in the LPS-16A Data Logger, which is located in the upper sphere. The types of information that are presently recorded on tape are as follows:

(1) Time in minutes and seconds in BCD.
(2) Time in days and hours in BCD.
(3) Heading in degree counts.
(4) Pressure in foot counts (depth).
(5) Temperature in degree (C) counts.
(6) Motor Voltage in volt counts.
(7) Motor Current in ampere counts.

Before continuing further into the discussion, the reader should go back and carefully review sections 2.3.5 Data Storage, 2.3.6 Sensors, and 2.3.7 Data Conversions. In order to understand the limitations of the data collection system, it is necessary for the user to be shown the tape format. Refer to Figures 4.1 and 4.2. Note in Figure 4.2 that the first and second words are recorded as binary coded decimals, and that the third word is binary coded but with eight of the sixteen bits wired low. Words four through eight are recorded as binary numbers along with their channel assignments.

Figure 4.3 shows a block diagram of the system designed to retrieve the data recorded by the Vertical Profiler. The system consists of a cassette tape reader Model 3122 manufactured by Memodyne Corp, Newton Upper Falls, Mass.; a code converter produced by NORDA; and an NP7B Numeric Printer manufactured by Gulton Industries, East Greenwich, Rhode Island. The cassette tape reader extracts the stored data from the tape and produces eight 16-bit words from each recorded file. These are a mixture of binary and binary coded decimal numbers. Their formats were shown in Figure 4.2. These 16-bit words are routed to the code converter where they are processed to convert them all to binary coded decimal which can be accepted by the printer. The individual data words in each file are printed sequentially onto a paper tape roll.

The first and second words which provide time are printed as direct readouts as shown below and require no conversion.



*See Figure 4.2 for a description of each word.

NOTE: Both the LPS-16 Cassette Data Logger and the Memodyne Cassetté Tape Recorder are hard wired to use the eight-word-per-file format shown above.

Figure 4.1 Data Logger Tape Format

1st WORD — digits: 0 5 9 5 9 LSD*

SS 00 101 1001 101 1001

Word GAP — SS; Hard Wired to "0" — 00; MINUTES — 101 1001; SECONDS — 101 1001

2nd WORD — digits: 3 6 5 2 3

SS 11 0110 0101 10 0011

Word GAP — SS; DAYS — 11 0110 0101; HOURS — 10 0011

3rd WORD

Counts from 0 to 255

SS 00000000 11111111

WORD GAP — SS; Hard Wired to "0" — 00000000; HEADING — 11111111

4th WORD

Counts from 2078 to 4095** Chan 0

SS 100000011110 0000

111111111111

Word GAP — SS; PRESSURE

5th WORD

Counts from 1577 to 3277 Chan 1

SS 011000101001 0001

110011001101

Word GAP — SS; TEMPERATURE

6th WORD

Counts from 2048 to 3072 Chan 2

SS 100000000000 0010

110000000000

Word GAP — SS; MOTOR VOLTAGE

7th WORD

Counts from 2048 to 2480 Chan 3

SS 100000000000 0011

100110110000

Word GAP — SS; MOTOR CURRENT

8th Word

Count Range Undetermined Chan 4

SS XXXXXXXXXXXX 0100

Word GAP — SS; Data Type Undetermined

FILE GAP SSSSSSSSSSSSSSSSSS (18 sync bits)

*LSD means Least Significant Digit (2^0 position). All LSD's are to the right.

**The minimum and maximum values within the count range are expressed in binary, respectively.

Figure 4.2 Data Logger Word Format

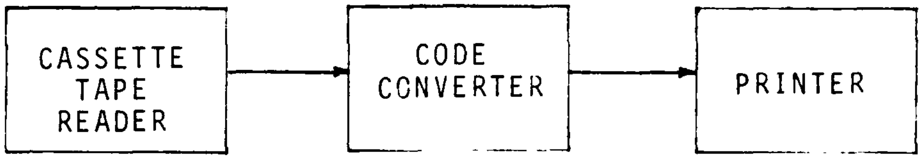


Figure 4.3 Data retrieval system block diagram

The third word, indicating magnetic heading, is printed as a decimal number that is only the decimal equivalent of the stored binary data from the heading sensor. As indicated in section 2.3.7, this number must be multiplied by a conversion factor to obtain the magnetic heading in degrees.

The fourth, fifth, sixth and seventh words (representing pressure (depth), temperature, battery voltage, and battery current, respectively), are each printed as the decimal equivalent of their sensor-generated binary data, not converted to engineering units along with their channel assignments.

As presently configured, the signal line for channel eight is not used for data, but is utilized to provide a tape advance signal to the printer to produce a space between each printed file. Figure 4.4 illustrates the printout for words three through seven.

PARAMETER	PRINTOUT	WORD #
Battery current	2070 03	7
Battery voltage	2310 02	6
Temperature	0738 01	5
Depth	2075 00	4
Heading	210	3

Figure 4.4 Data printout sequence

The present configuration of the vertical profiler allows for the gathering, storing, retrieving and printing of several specific types of data. These seven represent only the ones chosen for engineering and testing. The versatility of the vertical profiler is such that the user can utilize any type of sensor whose analog outputs are in the range of ± 5 volts or whose digital outputs are 16-bit words or less.

5.0 MAINTENANCE

To service the hydraulic system, mount the profiler in the servicing stand such that the upper and lower spheres can be rotated into the vertical.

5.1 HOUSING REMOVAL

(1) Remove the top portion of each sphere simply by removing the clamp rings. The upper sphere cover contains the pressure transducer, and it must be unplugged from the chassis for complete cover removal.

(2) Locate the switch panel in the upper sphere. Use the appropriate switches to turn ON power, to RESET the logic, to turn OFF the pump, and to CLOSE the valves.

(3) Rotate the lower sphere so that the bladder housing is UP.

(4) Remove all components down to the bladder itself. Removal of the bladder is done more easily when it is empty; but this is not easily achieved, since inverting the system and opening the valves will only expand the bellows about half way.

(5) Rotate the sphere so that the bladder is DOWN.

(6) Remove the bladder; be careful not to spill the residual oil. The closed valves in the system should prevent any significant leakage from within.

(7) Rotate the sphere so that the bladder connection point is UP.

(8) With the bladder structure and clamp ring removed, the cover may be raised off the hydraulic feed-through. Any part of the hydraulic plumbing system can now be removed, cleaned or replaced.

5.2 VALVES AND FILTERS

The valves in the hydraulic system normally require no maintenance if the system has been thoroughly cleaned and all foreign matter removed. A leaking valve requires draining the hydraulic fluid, removing the pump/housing lower hemisphere, and disassembling of the valve. The two Skinner valves may be disassembled without removal from the system, however. This is done by removing the operating coil assembly and removing the valve bonnet with the special spanner nut attached to the plumbing. Examine for minute particles which might prevent full closure. Blow out valve body with air, reassemble and leak test.

The three 20-micron filters in the system should not require cleaning once the system has been flushed and filled with clean oil. However, it is a good idea to clean them every time the system within the pump housing is opened for any other purpose. The filters are cleaned by reverse flushing with a light solvent such as mineral spirits or kerosene.

5.3 OIL REPLACEMENT

To refill the hydraulic system after repair or cleaning:

(1) Rotate the lower sphere so that the bladder ttachment point is DOWN.

(2) Remove the circuit card on top of the bellows and lay it on its side to gain access to the bellows vent ports. Take care that the circuit is insulated from the metal housing. Open the vent plugs on top of the bellows.

(3) Fill the bladder with EXXON Univis J13 (formerly Humble Univis J43). This will require about 2.5 gal (9.5 liters).

(4) Connect a 3 m fill hose to the bladder.

(5) Carefully squeeze the air out of the bladder that the hose will fill with oil.

(6) When all the air has been removed, connect the fill hose to the bladder port on the sphere.

(7) Invert the bladder, elevate it to one meter above the bellows, and check for leaks.

(8) Turn power ON in both spheres, turn the pump OFF, and OPEN the valves. The system is now set to gravity drain from the bladder to the internal bellows.

(9) Monitor the vents and insert the plugs when the oil reaches their level.

(10) Bleed any remaining air from the bellows when it has expanded to about 50% of maximum since, when fully expanded, it produces a fluid head of 1000 mm. A small amount of residual air will not affect the system operation; however, reasonable effort should be made to remove as much as possible.

(11) Wipe up any vented oil when the air bleeding is completed. Reinstall the circuit board and continue the gravity feed. The bellows will expand until it reaches the upper limit switch, which will automatically close the valves and stop the oil flow. This will take about 10 minutes.

(12) Lower the bladder to the floor once the bellows are full and the valves are closed.

(13) Remove the fill hose from the bladder port on the sphere.

(14) Drain the remaining oil from the bladder completely.

(15) Measure 600 ml of oil and pour into the bladder. This is the correct amount of residual oil for the system.

(16) Attach the bladder to its normal fitting while carefully squeezing the bladder to vent any air as the connection is made.

(17) Rotate the sphere so that the bladder is up and reinstall all supporting and containing items. PAY SPECIAL ATTENTION TO THE FOLLOWING:

(a) When replacing the lower cover, it is important to align the pin on the hydraulic feed-through with the pilot hole in the cover. This prevents the rotation of the feed-through when the assembly nut is tightened.

(b) The bladder housing mounting ring must be aligned with the mounting bar of the cage for shipping restraint.

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The Ocean Programs Office (Code 500) of the Naval Ocean Research and Development Activity (NORDA) provided funds during Fiscal Years 77, 78, and 79 to the Ocean Science and Technology Laboratory (Code 350) for the development of a versatile ocean profiler capable of carrying a variety of sensors. The NORDA Vertical Profiler and associated data readout system resulted from this development effort. The Profiler is capable of making water column measurements from the air/sea interface to a depth of 1000 meters and returning to the

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surface approximately 20 times before its lithium energy source is expended. Sea tests have been conducted using temperature and depth sensors with the data acquisition subsystem, and a conductivity/temperature/depth sensor capability is also available. The data acquisition subsystem within the Profiler can accept up to 16 analog inputs properly scaled in voltage, and any number of serially supplied 16-bit digited words. Limited amounts of power are available from the Profiler to power add-on sensors. The Profiler is cycle programmable and can be commanded to ascend and descend at regular prescribed intervals. Data rates, sample intervals, and sample durations are also pre-selectable. One of the most significant and unique features of this profiling device is its ability to make measurements up to and through the air/sea interface.

The Data Readout Subsystem permits retrieval and printout of sensor data collected by the Data Acquisition Subsystem during profiling operations. This subsystem can easily be interfaced to desk top calculators for automatic processing of data or preparation of digital magnetic tape for data entry into a large computer.

This manual describes the functional operation, interconnections, alignment, checkout, and predeployment procedures needed to make use of the NORDA Vertical Profiler. Because the buoyance subsystem of the Profiler is based on fluid-induced volumetric changes, there are maintenance requirements typical of hydraulic systems. In addition, the self-contained battery subsystems, which supply energy to the various valves, pump, motor, control and sensor electronics, require replacement or recharge on a periodic basis. It has been a primary goal in developing this manual to preserve the detailed information necessary to proper maintenance and operation of the Profiler hardware and not to describe the spectrum of applications to which this device might be put.

This system is available to ocean researchers. Those having an interest in making use of this system should contact the Ocean Programs Office at NORDA.

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